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J. F. DASHIELL, PH.D., CONSULTING EDITOR

GENERAL PSYCHOLOGY

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GENERAL PSYCHOLOGY

BY

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To

HILDA

PREFACE

Scientific psychology seeks to discover and record the measurable aspects of human conduct. To the imaginative student it may seem to be a pedestrian sort of approach devoid of those penetrating insights which the unencumbered fancy of poet and dramatist give. Bent upon measurement and forced to furnish proof for each generalization, the laboratory scientist often seems to be giving us merely a quantitative expression for the obvious, and an accumulation of minutiae which—lacking imaginative interpretation—are devoid of meaning. He accumulates a mountain of measurements, but somehow misses the soul of his subject.

Nevertheless, his pedestrian labors extending over the past century have yielded products of increasing value. While the avowed aim—to predict and control human behavior—is still much more of a hope than a description of accomplishments, no one who is concerned with human problems can neglect his findings. Although our actions and words sometimes seem to be, as Mark Twain called them, "but the clothes and buttons of the man," through the painstaking study of these events which are open to the observation of all the psychologist has found many of the mechanisms at work in human conduct. If his net of measurement is still too coarse to enable him to plot with any accuracy the dynamics of thought and imagination, at least the main outlines are beginning to show through. In the meantime his many blunders have done something to refine his logic and his experimental methods, and it is his hope that by a continuing series of successive approximations he may arrive at an adequate account of "the man himself."

The present textbook is the outgrowth of some sixteen years' experience in lecturing to undergraduate students in psychology and represents an attempt to present the main outlines of the psychologist's findings. Necessarily it is highly selective, for no single volume could do justice to the present flood of psychological research. (The 1937 volume of *Psychological Abstracts* lists over six thousand titles!) It is hoped, however, that the problems selected for treatment are of such fundamental nature and represent such varied

techniques that the student may gain a glimpse at least of the total field of endeavor.

In view of this purpose the author has not attempted a logic-tight systematic presentation of a single viewpoint, with heavy stress upon a preferred experimental procedure, and in the most disputed territories he has tried to give a sympathetic account of opposing views and to permit the reader to draw his own conclusions. There is little doubt, however, that the author's preferences and biases have loaded the dice and in the interest of clarity it might be well to state them frankly. Let the student beware, therefore, of a behavioristic bias, and of a preference for physiological and mechanistic descriptions of thought and action. If Watson erred in excess of zeal—and, in casting out the spooks and demons that we inherited from medieval psychology, threatened to banish those thoughts, images, and percepts which are of more legitimate psychological concern—his criticisms of a barren self-contemplative introspectionism still remain a wholesome and potent influence in American psychology. And like many others of the behavioristic persuasion the author confesses to a strong environmentalist bias.

These biases have not prevented him, however, from making use of introspective findings where these seem to illuminate the problem under consideration, or from presenting fairly extended (and we hope reasonably sympathetic) accounts of the Freudian and Gestalt viewpoints. Both these views serve to correct and amplify the somewhat simple and rigid logic of a stimulus-response psychology couched in terms of neuromuscular elements and based upon the results of animal experimentation.

Although the author has taken the human individual as the object of his study, he has borrowed heavily from the comparative psychologist and has attempted, particularly in the discussion of the nervous system (Chap. II) and of development (Chap. V), to show both likenesses and differences between man and animal. In addition he has tried to show the social bearings of his generalizations; and this has seemed of particular importance in view of the fact that the social question is *the* question of our times.

In a textbook which endeavors to acquaint the student with the outstanding experimental studies and theoretical formulations within the field of modern psychology, the author's indebtedness must necessarily be great. He has tried to indicate this in proper citation and acknowledgment, hoping, in addition, that the student will be

led to explore some of the sources and discover for himself the greater satisfaction in firsthand information. To the many publishers and authors who have so courteously helped by granting permission to use published materials the author hereby acknowledges his gratitude and indebtedness.

To his colleagues at Oberlin, R. H. Stetson, L. D. Hartson, and H. E. Weaver, the author is particularly indebted, since most of the psychological notions herein expressed have taken shape in the seminar discussions held weekly over the past years. They have provided the stimulus and challenge without which thinking is impossible. To Professor Stetson, in particular, who first introduced the author to psychology and who continued to encourage him through his years of graduate study and teaching, he owes, in addition to guidance and encouragement, whatever of grounding in basic psychological theory he has achieved.

L. E. Cole.

Oberlin, Ohio,
June, 1939.

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GENERAL PSYCHOLOGY

CHAPTER I

ANIMISM AND BRAIN PSYCHOLOGY

Primitive Animism

Introduction.—To predict and control, and to reduce a chaotic mass of facts to an intelligible system—these are the aims of science; and when they are directed toward the field of human behavior, psychology emerges. Now, these aims are really much older than scientific method, and man's interest in his fellows runs back, of course, far beyond the written history of the race. The beginnings of psychology are found, therefore, embedded in myths, folklore, in magical and mystical notions, in primitive religions. And while it is not our purpose to write a history of psychological notions, it is fitting that we examine some of the earlier notions, for the fallacies of the past have a way of getting themselves incorporated in the popular notions of the present. A brief study of "origins" will help us to be critical of contemporary theory.

How strange the early attempts to predict and control appear to us now. Proud of our fresh conquests we do not like to recognize in the magic of the medicine man, the rain maker, the harvest ceremony, the humble beginnings of the labors of the physician, the Weather Bureau, the Department of Agriculture. Though to modern man they seem as far apart as the poles, as we move back toward the beginning of our written record we reach the point where science and magic are rather indiscriminately mingled. Consider, for example, the *Natural history* of Pliny, a compend of the knowledge of his time (A.D. 23–79).[1] In the section dealing with medicine we discover that certain medicinal herbs must be gathered by moonlight, that an epileptic may be cured by driving an iron nail into the

[1] "In the preface the author claims to have stated 20,000 facts gathered from some 2,000 books and from 100 select authors." J. E. Sandys in the *Encyclopaedia Britannica.*

spot where his head rested when he fell in the fit, that a boil may be removed by rubbing nine grains of barley around it, each grain thrice with the left hand, and then throwing them all in the fire. Astrology and witchcraft exist along with a critical attitude, and a credulous dependence upon hearsay evidence often replaces the supporting facts which the skeptical modern has been trained to demand.

It is hard for the modern mind, contemplating this mixture of sense and nonsense, of fact and superstition, from the superior vantage ground which centuries of accumulated experience have given to refrain from the judgment that these minds were somehow inferior to our own. Surely we could have penetrated this sham knowledge. Surely we could have risen above the superstitions of our contemporaries. Against such a supercilious view, however, modern psychology and anthropology are united. The mind of man does not rise above the level of his contemporaries—save in the case of the isolated genius who transcends his fellows ever so little in the historical perspective—and progress in rationality has come about through a social process and not through any change in native wit. (Certainly this judgment applies to the progress of the last 25,000 years.) If primitive man was more impressed by coincidences and superficial resemblances than we, it was because his fund of accumulated and recorded observation was so small, his practical control of his environment so limited. Like the fisherman, his "lore" was rich and complex, full of exceptions and excuses, and for the very reason that he, like the fisherman, depended upon "luck"—not knowledge. And the primitive "expert"—the medicine man—no doubt did his bit to perpetuate error; for his power and prestige depended upon the continued credulity of his clients. If his incantations and advice failed, it was because his client was unclean, had offended the spirits, had made some minor error in the ritual, etc.

Primitive Practice and Primitive Theory.—And so, whatever his native wit may have been, we find our primitive attempting to destroy an enemy by making a waxen or wooden image of him and then piercing, tying, burning, or mutilating the image. Or we find him devising dances with much leaping in the air, hoping thereby to make the corn grow tall. Or we find him tying a petticoat around a tree to make it bear fruit. Or, as was once the custom in a village near Dorpat, in Russia, he attempted to produce showers by an elaborate ritual.

> Three men used to climb up the fir-trees of an old sacred grove. One of them drummed with a hammer on a kettle or small cask to imitate thunder; the second knocked two fire-brands together and made the sparks fly, to imitate lightning; and the third, who was called "the rain maker," had a bunch of twigs with which he sprinkled water from a vessel on all sides.[1]

Many and curious are the beliefs and practices with which our ancestors attempted to control nature.

What sort of psychology did this credulous one devise, where experiments were left to a capricious nature, and records kept in the memory of interested medicine men? The key to his conception of human conduct is found in his explanation of that primary fact, the contrast between the living and the dead. As he attempted to explain this it seemed to him that when this body that is now active, sensitive, struggling, suddenly becomes inert, lifeless, silent, insensitive, something—call it mind, soul, a vital spark, the breath of life—has gone out. Just as the modern vitalist makes use of an *élan vital* in his biological speculations, primitive man pitched upon various substances to explain this contrast. What is today an attenuated and insubstantial principle was in the first place a sensible something—the shadow, the breath, the blood, or fire, or air. Dead men cast no shadows, and lassitude overcomes one in the noonday heat of tropical sun when the shadow is shortened. The dead are cold, and do not breathe, and loss of blood all too often is followed by death. Thus did nature arrange sequences for her early problem solvers, and now one item and now another served to rationalize the phenomena. The belief in an internal something which pushed the inert flesh, some spring of life and activity, at whose departure the body lost its powers, was universal.

The Soul Concept as a Key to Primitive Conduct.—This material "soul," or pusher, became the nucleus around which clustered man's interpretations of his behavior. It may have been an absurd "hypothesis" but its reality was never questioned, and it served at once as an organizing and systematizing principle for his knowledge of his fellows and as a basis for his conduct. Primitive man partook of certain foods and avoided others because of what they were supposed to do to the soul. He avoided awaking a sleeping fellow too suddenly, because in so doing he might startle the soul to such an

[1] From Fraser, J. G. *The golden bough*, abridged ed., p. 63. New York: Macmillan, 1922. Reprinted by permission of The Macmillan Company, publishers.

extent that its return to the body would be prevented. He cut a hole in the side of his hut, to let out the soul of the dying man, and then covered up the place so that the soul would not be able to find its way back, to haunt him. He buried the weapons, clothing, belongings of the dead warrior—and sometimes even his wife and slaves—so that these might give comfort to the departed shade. He sometimes stooped to catch the dying breath of the brave warrior, in order that by breathing it in he might likewise become brave. He looked at the hollow tubes in the body, sometimes exposed in the wounded warrior, and saw in these the channels through which the soul substance was able to reach the finger tips, and activate all parts of the body, not knowing that they were the blood vessels. In short, the soul provided him with an understanding, and a plan of action. He could explain dreams, in which he seemed to be wandering in some distant place, as a wandering of his soul. He had an explanation of death, and out of this he conjured up a view of an afterlife. One is bound to be impressed, I think, with the numbers of men who have held this soul belief. Greek, Egyptian, European, Asiatic, Aztec Indian, Polynesian—all have had their version of the soul, of its wandering, its reincarnation, its temporary voyage here below in this body-prison, and its final ascent to some more perfect existence, a happy hunting ground, an isle of the blest.

It is possible that in this saga of the soul and its wandering, and especially in its future life, there were emotional and aesthetic satisfactions which far outweighed the practical uselessness of the doctrine. When life was hard, the primitive could think that the soul was but a traveler, tarrying for a little while, bound eventually on a journey for some fairer resting place. When life seemed oppressingly short, he could remember that the life of the soul stretched on into the infinite distance. When his dreams far outran his accomplishments, he could remember that the inferior materials of the body were not calculated to give expression to the true essence within him. Soul and body come very near to representing the dichotomy between wish and reality. Perhaps this accounts for the persistence of the notion.

Inadequacy of the Soul Concept as a Principle of Explanation.—Certain it is that, confronted with a practical and material reality, the soul conception did not prove to be particularly fruitful, and the explanations based upon it had a strangely post-mortem character. Imagine, for example, the scene in which a primitive wise man

learned in this science of the soul came upon an apparently dying warrior. Perceiving the cessation of movement he comments, "He's going to die. The soul is leaving his body. That is why he is so quiet. He'll fight no more." Here is explanation and prediction. But if, perchance, the warrior should recover, and begin to stir, this primitive wise man would be obliged to say, "See! He is reviving. That is because the soul is returning to the body. He is going to recover, and will live to fight another day." Note that the explanations and predictions are made *after* the changes in behavior occur. Since the predictions could be made with equal validity, without reference to the hypothetical soul, this latter concept does not seem to add much. And as the soul became, with the passage of time, an increasingly immaterial thing, the possibility of proving or disproving any of its qualities or functions grew less, and its scientific value fell to zero. In its earliest and most material forms (as blood, or breath) it had its possibilities—it could be observed, studied, located. So it was housed in the heart, the liver, the blood vessels, the diaphragm, the bowels, the cranium; but as the functions of the various organs have yielded to physiological research, the soul has led a hunted existence. Perhaps the present-day tendency to locate all consciousness in the cranium represents a last stand of primitive animism, made possible by the complexity of the problems of brain physiology. When we examine, in more detail, the early physiologies we shall see to what an extent the soul notion prevailed; and when we discover the reasons which led the earliest investigators to locate consciousness in the brain we shall be prepared to examine more critically our current popular conceptions.

Although it seems fair to say that the elusive and indefinable soul is a thing of the past, as far as science is concerned, the ways of thinking generated by the soul idea during many centuries, still persist. When we speak of the action of the mind upon the body, of the power of consciousness to cause movement, we are well within the soul tradition. Although, like John Brown's body, animism is officially dead, its soul goes marching on.

The Physiology of the Soul in Ancient Greece

So many of our traditions, scientific and philosophical, stem from the Greeks that it is appropriate to examine briefly their notions of the soul. As they sought to discover the basic elements which compose the universe they pondered, too, upon the question of the

composition of the soul substance. Of the elements which they considered, earth, air, fire, and water, each one—with the exception of the earth element—appealed to one philosopher or another as the soul-forming substance. The soul is composed of fire, argued one, attracted by the active nature and the heat-giving property of this element. And another chose vapor because vapor is composed of the finest particles in ceaseless flux. Others argued for air, seeing the life-giving breath and noting that air has just the capacity of penetrating everywhere which would enable it to fill the interstices of the body and reach remote tissues. If their discussions seem strangely divorced from the practical issues which they had to meet, that is simply because we have found much more satisfactory theoretical substitutes. Certain it was that their theories provided the early Greek physicians with working hypotheses, a rationale of treatment; and around these notions the philosophers built what seemed to them an understandable world system.

And it is not without reason that the historian points to the Greeks as the founders of scientific medicine, for within a period, dating roughly from the sixth century B.C. to the second century A.D., these early physicians developed a tradition of healing, of painstaking observation, achieved the rudiments of a physiology and anatomy, practiced dissection upon animals—and occasionally upon men—and achieved the concept of bodily constitution or temperament.

One serious handicap, perhaps the greatest, was the taboo which prevented them from practicing human dissection. In commenting upon the training of Galen, one of the best known of the Greek physicians, Singer[1] tells of a journey to Alexandria, where the young physician "improved his anatomical equipment, and . . . examined a human skeleton." And the historian adds, "It is indeed probable that his direct practical acquaintance with human anatomy was limited to the skeleton." For the most part they drew their anatomical knowledge from dogs, calves, pigs, bears, and Barbary apes, although for a brief period (from 300 to 200 B.C.) human dissection was permitted. Even then it was sharply limited, the condemned criminal offering the principal source of material.

During the period when dissection was permitted the nerves which enter the brain and spinal cord were discovered. There was some

[1] Singer, Chas. Joseph, writes an interesting account of Galen in a chapter on biology in *Legacy of Greece*. Ed. by R. W. Livingstone. Oxford: The Clarendon Press, 1921.

interest in the anatomy of the eye, and its lens and coats were described. The brain itself was studied, although interest centered in the ventricles, hollow cavities which offered—they thought—an ideal place for the seat of the soul.

But perhaps the most serious handicap of all was the animistic cast to their thinking, which led them to look for "spooks" and to ponder over the distillation of "animal spirits" from the food, instead of the more matter-of-fact problems which later science has chosen. For all that these pioneers accomplished modern science is forever indebted; but, as we shall see in examining the leading ideas of three of these men—Hippocrates, Aristotle, and Galen—their thinking took place within the framework of primitive animism. We shall see how this framework warped the earliest scientific observation, and set up a tradition from which we are escaping today, tardily, and in some quarters with reluctance.

I. Hippocrates (ca. 460–377 B.C.).—Half legend, half man, Hippocrates furnishes us with the Greek ideal of physician and scientist. In the "Hippocratic oath" the physician swore to keep his life and art "in purity and holiness" and to adopt a regimen which should be "for the benefit of the patients."

And beyond these protestations there is clear evidence in his writings that the physician's duties were pursued with a genuine scientific interest. Some forty-two records of clinical observations have survived and show his interest in accurate observation. For example, there is the case of

> The woman with quinsy, who lodged with Aristion: her complaint began in the tongue; voice inarticulate; tongue red and parched. *First day*, shivered, then became heated. *Third day*, rigor, acute fever; reddish and hard swelling on both sides of neck and chest; extremities cold and livid; respiration elevated; drink returned by the nose; she could not swallow; alvine and urinary discharges suppressed. *Fourth day*, all symptoms exacerbated. *Fifth day*, she died.[1]

Of all the hundred or more works associated with the name of Hippocrates, none offers a title more suggestive than that of the *Prognostics*. Prognosis, the prediction of the future course of the disease, based upon the observation of present symptoms, requires a background of standardized observations, and in the clinical notes

[1] Singer, *op. cit.* Reprinted by permission of the publishers.

of Hippocrates we can see this background in the process of being developed.

But we should not make Hippocrates too much of a modern. It is but natural, in the light of what we know of the ideas of his predecessors and teachers, that he should have been impressed with the importance of the four great elements. And so we find him arguing that as the composition of the body varies (giving predominance to earth, or fire, or air, or water) so the temperament of the individual will vary (sanguine, bilious, melancholy). While these elements (and the corresponding fluids, or humors, of the body) may vary from time to time, either through exposure, advancing age, or faulty regimen, they tend—in general—toward an equilibrium, and it is the duty of the physician to assist nature in achieving harmonious balance. Especially important is the balance between *fire*, which moves and consumes, and *water*, which nourishes. The condition of the pores is important, for the soul substance, *air*, is absorbed through them. Veins and arteries convey both blood and air; in fact, the pounding of the pulse is due to the shock of air meeting the blood.

To the brain Hippocrates assigned the most important place. He believed that the veins of the body originated there, that these carried the humors to the various tissues,[1] that disease consequently began in the brain, and that, finally, the brain was the seat of intelligence. It is with a shock that we realize that, like his contemporaries, the principal reason for this last opinion is found in the fact that the ventricles, or cavities, seem so well adapted to retain the air, and hence to furnish a reservoir for the soul, with outgoing channels through which it can communicate to the body.

Thus Hippocrates held forth against those of his contemporaries who would locate the seat of the soul in the diaphragm, or in the heart, arguing that the activity which we feel in these organs during emotional stress is a secondary or reflex disturbance. The primary occurrence is to be sought in the constriction of the air vessels.[2]

[1] Among the Greeks veins, arteries, and nerves are confused. The latter were believed to be tubes, as is shown in Alcmaeon's opinion that blindness or deafness due to concussion is explained as due to a shift and consequent blocking of the channels through which substance flowed from eye or ear.

[2] Twenty-three hundred years later psychologists are involved in a controversy as to whether the visceral changes in emotion are primary or secondary, and the logic involved in this later controversy is not vastly different from that employed by the Greeks. Cf. discussion of the James-Lange controversy, in Chap. VI.

And so, on excellent authority, human intelligence was officially ensconced in the cranium. Hippocrates would have understood the gesture which sometimes accompanies our phrase, "Nobody home"; for he saw the cavity in the cranium as perfectly suited to house the *pneuma*, the air substance which, in his opinion, was so important a regulator.

II. Aristotle (384–322 **B.C.**).—In the works of Aristotle we find not only a synthesis of the knowledge of his time, but accounts of experimental work in a variety of fields, adding notably to the sum of human knowledge. His discussions of the relations between the different species of animals are frequently regarded as the forerunners of our own notions of evolution, and his dissections of animals, his anatomical drawings, certainly mark him as an important founder of the science of biology.

But Aristotle, too, was impressed with the soul doctrine. He repeated many of the speculations of Hippocrates concerning the nature of the four elements and their various combinations, producing the humors and the different temperaments. In fact, this doctrine was held as late as the nineteenth century, although by this time chemistry had already started scientists on a different route.

And Aristotle added some new nonsense of his own. Or rather, backed by different sources, he challenged the ruling Hippocratic tradition of brain dominance. Most of his contemporaries were quite certain that the center of control, the central office of the soul, was located in the cranium, and his successors again drifted back to the notion. Aristotle, on the contrary, argued stoutly in favor of the heart. In fact, he believed that the brain was little more than an evaporating and cooling system, in which the warm vapors which arose from the stomach were cooled and fitted for circulation through the body.[1]

Against the notion that the brain is somehow important as a seat of intelligence, he pointed out:

1. The brain is insensitive to touch. Trephining operations in which portions of the skull were removed had been common for centuries and were frequently recommended by Hippocrates and his pupils. Undertaken, no doubt, to relieve a soul disturbance, they gave opportunity, nevertheless, for such observations as Aristotle now emphasizes.

[1] Thus, he argued, when we nod after a heavy meal, this is but natural since with the condensation of this vapor the head becomes heavy.

2. The brain is not found in the simplest invertebrates. It seems natural, therefore, to argue that life, activity, responsiveness to stimulation, is in no wise entirely dependent upon this organ.

3. The sense ducts lead to the heart. The Greek confusion between veins and nerves enabled Aristotle to make this statement.

4. The heart is the last to die. When it stops mental life stops.

5. Loss of blood is accompanied by insensibility.

6. The heart is affected in profound fashion by pleasure, pain.

7. Its very position, central within the organism, shows a neat adaptation between form and function. It is suitable as a controlling center.

The serious vein in which these arguments are advanced should remind us, as moderns, when our own introspection seems to give proof for the location of our thoughts up in the cranium that Aristotle's introspection placed them, with equal vividness, elsewhere. And we should look upon the scriptural language which describes man as thinking, reasoning, believing, deciding in his heart, as more than mere figurative language. It does, indeed, represent the serious beliefs of the time.[1]

Aristotle tried his hand at a kind of chemistry of the soul too, looking at it as a kind of compound of blood and air, a double distillation of the food which nourishes us. Cooked in the stomach by the animal heat, the vapor rises through the blood vessels and, condensing, becomes blood. By some further process, the nature of which is by no means clear, a purified pneuma appears.[2] This pneuma receives impressions from the outer world, transmits them to a central reservoir. This last in turn controls the muscles and tendons which produce movements. In all this Aristotle differed little from his contemporaries. The chief point which differentiates him lies in the location of this central reservoir; and Aristotle, for the various reasons which we have noted, chose to name the heart.

[1] Norlie, O. M., in *An elementary Christian psychology* (Minneapolis: Augsburg, 1924), published for devout Lutherans, has an excellent collection of Biblical passages calculated to prove that, when Holy Writ locates the soul in the heart, it does not do so by chance. Although published in the twentieth century, the book is a serious endeavor to convince its young readers of the truth of this early doctrine. It is an excellent example of primitive animism.

[2] One is bound to see in the modern discussions of mental energy a revival of analogous concepts. Professor McDougall, for example, stresses the importance of a substance which he believes to be secreted by the nerve cells. This *neurokyme*, as he calls it, for all the chemical language in which it is described, must for the present be described as a ghost-soul. Its functions are the functions of Aristotle's pneuma.

III. Galen (ca. A.D. 129–200).—With Galen, the third of these Greek scientists and medical men, the productive period of Greek biological science closed. His writings, which gave the final synthesis to the study and speculation of the period, set the pattern for both medicine and biology for the next thirteen centuries.

By the time Galen had appeared the practice of human dissection had been discontinued, and aside from the work upon animals, and the occasional study of the human skeleton, he had no firsthand sources. To the modern student Galen seems, frequently, more interested in verbal matters than in matters biological; more interested in showing the usefulness of a particular organ (or in pointing out the wisdom of the Creator in fashioning each and every structure in its exact form) than in the accurate description of its functions.[1]

In Galen's writings the physiology of the soul reached a complicated formulation. A rather material affair, this soul seems to be present in the body in much the same way that a chemical is present, and he was prepared to draw up a regimen which would affect the personality of man by altering the composition of his soul.[2] Climate and diet, air and food, wine, drugs, baths, exercise—all produce their effects through alterations in the composition of the *animal spirit*, as Galen called the most rarefied of his soul substances. From food and air this animal spirit draws its components. The air, drawn into the lungs, is mixed with the blood. The blood seems to have the role of a second-grade spirit, the natural spirit, and was manufactured from food substances by the liver. From the liver the blood ascends to the heart and is purified through the action of the air drawn into the lung in respiration and conveyed—as he believed—directly to the left ventricle of the heart. From the heart the now purified spirits, called *vital spirits*, ascend to the brain where a further purification takes place and they become "the noblest essence of all, the *animal spirit*." When this refined substance acts through the nerves (believed to be hollow tubes) it serves to produce and control the highest functions of the organism. So we might say that Galen was inclined to attribute intelligence to the brain, desire to the liver, and to the heart vitality, courage, temperament.

From Galen to the Middle Ages.—From the time of the Greek medical men to the close of the Middle Ages, nothing of importance was

[1] Singer describes his works as "vast, windy, ill-arranged treatises." *Op. cit.*

[2] In some of the work of the modern endocrinologist Galen would have seen a complete justification of his ambitions.

discovered, and an account of the various doctrines held would amount to a series of variations on the themes of Galen. The church fathers, into whose hands so much of the business of preserving and imparting knowledge was committed, were interested in the salvation of the soul, the construction of the city of God, and not in the description or exploration of any earthly kingdom. The philosophers were not engaged in a study of man, but in the development of fine-spun theories of the nature of the universe, of spirit, of God. Their exercises in logic and cosmology may have sharpened the linguistic tools of later generations, but they contributed little or nothing to the progress of discovery.

Science, flourishing for a little while in Greece, fell into the doldrums. Physiology could not advance, for the dissection method had been almost wholly abandoned and was not revived until the sixteenth century (Vesalius, 1514–1564).[1] Medicine fell to the low estate of sheer quackery for the most part, and the physician of the 1200's did not need to interview his patients in order to write his prescriptions; it was done automatically, thanks to the astrologer's calendar. The day of the patient's birth and the planets in ascendance at the onset of the disease were far more important than the physical symptoms of the patient.

With the beginning of the sixteenth century the theological-scholastic tradition began to give way before observation and experiment, and new discoveries began to pour in. But the notions which had grown up around the garbled versions of Galen, which had persisted as the only biological science for centuries, were slow to wane. Like Galen, men continued to think of the brain as the home of the mind. As their ancestors had endowed rocks, and their weapons, and growing plants, and animals—their whole world, in fact—with spirit properties, so through the centuries men continued to think that the skull box housed, in some vaguely apprehended way, the secret and the essence of the human personality.

Originally the soul had been located in many different places by different peoples, but the views of Hippocrates and Galen finally prevailed. At one time the brain seemed the likely home for the

[1] That the circulation of the blood remained a mystery until Harvey's discovery in 1628 serves to illustrate the lack of observation through these centuries. It is said that until the sixteenth century there had been a notion, repeated from one generation to another, to the effect that there was a bone in the heart, and that the walls of the heart were porous.

soul because it possessed hollow ventricles; at another time it was because of the network of nerves which seemed to join this organ with all parts of the body. With successive generations the reasons changed; but with the discovery of the nature of nerve action the matter seemed clinched. Up until this time tradition and the voice of authority had served to perpetuate the idea. Changing ideas of the natural world might lead to a variety of new reasons for "head dominance"; but none of the reasons was so closely founded upon scientific observation nor so stimulating to further research as the views which followed the discoveries of Bell and Magendie, at the beginning of the nineteenth century.

The Beginnings of Nerve Physiology

An experimental and physiological psychology had to await developments in physics and in biology. It was not until the eighteenth and nineteenth centuries that we find anything approximating the modern notions of the chemistry of digestion,[1] the cell structure of animal and plant tissues, the concept of "irritability." Psychology had to wait for physiology, and physiology in turn depended upon physics and chemistry for both tools and method. For example, the development of a compound microscope sufficiently free from chromatic and spherical aberration to permit the discovery and study of cell structure, was not completed until 1830 when Lister—an amateur optician—described the red blood corpuscles.

Thus, we may understand the survival of Galen's brand of animism into the eighteenth century, when the regius professor of medicine at Paris writes of the reflex in these words:

> As with light, angles of incidence and reflection are equal, so that a sensation produced by a concussion of the animal spirits against the fibrous columns is reflected and causes motion in those nerve tubes which happen to be placed exactly in the line of reflection.[2]

Here we find the animal spirits and nerve tubes of the Greeks, scarcely changed in two thousand years!

But within the first half of the nineteenth century important changes took place. The nerve tubes were replaced by the cell

[1] Some concept of the physics and chemistry of energy was necessary to lay the ghost of primitive animism, which had thought of the soul as the prime mover of human organisms.

[2] Boring, E. G. *History of experimental psychology*, p 40. New York: D. Appleton-Century, 1929. Reprinted by permission of the publishers.

bodies and their processes, the undifferentiated animal spirits underwent analysis and differentiation, and the nerve impulse was measured. Sir Charles Bell demonstrated (1811) that there were two sorts of nerves, motor and sensory, and Marshall Hall (1832) described movements in a spinal animal—movements which are possible without the intervention of the brain. In 1850 Helmholtz succeeded in measuring nerve impulses in the nerve of the frog, and later in human beings.[1]

These physiological discoveries altered psychological notions. For one thing, they showed that the methods of physics and chemistry could be applied to the behavior of living organisms, and the body's activities measured, and understood—within certain limits—in purely physiological terms. The animal spirits had been all-pervasive, incommensurable. With the work of Bell, Johannes Müller, Helmholtz, they began to give up their secrets, and as they did so animism began its retreat. The notion of involuntary action, growing out of the research of Hall, seriously altered the conception of the *anima*. When actions are possible in decerebrate animals, without the intervention of brain, then the anima ceases to be the sole mover. The peripheral nerves, moreover, were no longer tubes carrying "copies" of objects. Rather, they were fibers transmitting measurable impulses. Only in the recesses of the cerebral cortex did there seem to be any hiding place for the "mind."

Physiognomy and Phrenology

Physiognomy, a system of reading character from the external features—particularly of the head—is as old as the Greeks. Aristotle, to whom the first systematic treatise on the subject is attributed, devoted six chapters to the study. Curiously enough he relied mainly upon superficial resemblances between men and animals for his analysis, comparing man to the lion and woman to the leopard, and describing characters such as you might imagine. Thick bulbous noses, he thought, indicate swinish characteristics, insensitivity; sharp tipped noses reminded him of dogs, and irascible tempers; rounded noses reminded him of the obtuse nose of the lion, and magnanimity, etc.[2]

[1] In the motor nerve of the frog he found the figure to be about 90 ft. per second. In the human sensory nerve, slightly more than three times that amount.

[2] MacAlister, Alexander. Article on Physiognomy in the *Encyclopaedia Britannica*.

Those who founded such a view must have been convinced of the reality of the soul substance lurking within, and must have felt not only that it imparted its form and features to the body itself, but further, that it was immaculately conceived and impervious to experience. Character, they believed, was a kind of essence, present in the first instance, and not something manufactured out of the stuff of experience, out of a cultural medium, out of an environment. Like all preformists in biology, like the racialists of Nazi Germany, they looked upon character as inherent.

Even from the earliest times there have been skeptics. Galen clearly deprecated much of the then current physiognomical speculation, saying that it was possible to criticize such thinking, but that he did not wish to become involved in a tedious discussion.

But if the educated public has been generally skeptical and if, at times, legislators have paused to forbid extreme abuses in its practice, there have always been a large number who have felt that "there must be something in it." It is possible that this belief arises because the cues which regulate our adjustment to our fellows come so frequently from the face and head. In conversation we look closely at the mouth and eyes, we seek to read intentions; and the play of facial expression is as important as the words which are said. And centered as our attention is about the head, it is but natural that we should secure vivid impressions of the features and attempt to adjust to the stranger on the basis of surface resemblances, disastrous though it frequently is.

None of the published systems of physiognomy, from Aristotle to Katherine Blackford of our own time, is founded upon fact. Their evidence will not bear scrutiny in the light of scientific canons. The British biometrician, Karl Pearson, demonstrated this beyond the slightest doubt. And so we must throw overboard the idea that a strong will and a strong jaw are associated, that there is such a thing as the nose of the executive, the intellectual forehead, the musical ear (I refer to shape, of course), the sensuous lip. From gestures, movements, words, expressions, we may derive some basis for estimating the character of our fellows; but not from their physiognomy. The line in the forehead extending between the eyes may mean a tendency to frown, irritable disposition, poor vision, or a variety of other things. Like the lines in the palm which interest the superstitious, they indicate how the skin folds, nothing more. Similarly, the shape of the features may have some significance in indicating genetic, circulatory, or metabolic factors; but not the personality.

Lombroso, whose *L'Uomo delinquente* (1876) proposed to classify the criminal types on the basis of such features, was even prepared to sally forth to protect society by selecting the potential criminals and removing them from circulation. But just as Katherine Blackford's ideas have never achieved currency among trained vocational counselors, so the sociologist and the criminologist have little credence for the "criminal type."

Nevertheless, because of its persistence this notion must be described as one of the factors which have helped to center attention upon the head, and to perpetuate the tradition of "the mind in the brain." The shape of the facial mask has seemed important because it was thought of as concealing something just behind.

Beginning with the assumption that the brain is the organ of the mind (and this assumption had been dignified by more than fifteen hundred years of uncritical acceptance) the phrenologists argued that the peculiar developments of the brain should be correlated with peculiar traits of personality. There were then three tasks: the mapping of the brain into its anatomical divisions, the proper classification of mental functions, and lastly, the correlation of significant traits with the anatomical divisions. Apart from the empirical measurements the problem is a difficult one, and there is some question as to whether, after all the years that have passed since Gall, we have achieved a satisfactory classification of mental functions. Certain it is that each school has a working classification of its own, and the schools are by no means agreed. But the problem seemed simpler to Gall (1758–1828), and he constructed his list of 35 to 37 traits.[1]

Why he stopped at this particular number, or why he chose this particular list, is difficult to explain. Roget, the young English

[1] The list includes:

desire to live	cautiousness	marvelousness
alimentiveness	approbativeness	ideality
destructiveness	self-esteem	mirthfulness
amativeness	benevolence	imitation
philoprogenitiveness	hope	individuality
adhesiveness	reverence	configuration
inhabitiveness	firmness	size
combativeness	conscientiousness	weight
resistance	coloring	locality
order	calculation	eventuality
time	tune	language
comparison	causality	

lexicographer, could have extended the list of traits for him. When later, in our own time, psychologists consider the problem of *instinct*, this same logical problem of the number of significant traits returns[1] and it would seem that there are as many as one chooses to consider. Armed with his classification, and a collection of random observations he had cherished for years, Gall proceeded to fill in the missing "facts." Viewed by modern standards, Gall's bases for his anatomical-trait relations are the very scantiest. Apart from the fact that he had no adequate measure of his traits (and some of them would stump the modern "tester"), he made no effort to apply the simplest mathematical or logical tests to his data. Selecting his cases where he found them, he built up a "system." It is said that he located the bump of language behind the eyes on the basis of an early impression retained from his student days, when the young Gall was excelled by a classmate with protruding eyes. Adhesiveness he found in a lady introduced to him as a model of friendship, and because, he said, it is in the region where persons who are closely attached to each other put their heads together. He located destructiveness behind the ear, finding this "bump" on the carnivora (and in a young student who had been fond of torturing animals and later became a surgeon). Acquisitiveness he discovered in three pickpockets, the sense of tune in a musical prodigy of five, wit in the configuration of the heads of Rabelais and Swift.

Apart from all the shortcomings which are thus far apparent (the scanty data and the hit-or-miss method of collection, the arbitrary list of traits, and the blithe assumption that the anatomical divisions of the brain would neatly fit his classification), Gall did not trouble to consider those cases where skull measurements give a very unsatisfactory indication of the underlying brain tissue.[2] Since all his observation was made upon the skulls of the living, he must have made many predictions which his own system of logic could not justify. The variations in thickness of the membranes which surround the brain, variations in bone thickness, in spaces between bone and brain, prevent the skull contour from being taken as an index of the development of the underlying tissue.

In spite of its shallow foundation, phrenology flourished for a century.[3] It was never widely accepted within the academies of

[1] Cf. discussion in Chap V.

[2] Cf., *e.g.*, the case of hydrocephalic idiocy.

[3] According to Boring, the last phrenological journal ceased publication in 1911.

science, but it was espoused by many eminent individuals. Novelists took pains to give the correct phrenological description to their characters, and mothers took their sons to the visiting lecturer to have their heads "read" and their futures plotted in accordance with the talents which the phrenologist could see there, magazines were founded and clinics conducted. Against this interesting and much-talked-of conception the more recondite discoveries of the laboratories made slow headway. Phrenology might stimulate some men of science to fresh discoveries about the brain; but these discoveries, which were negative as far as phrenology itself was concerned, did not make their way so easily back into the popular notions. And so we may credit phrenology, on the one hand, with stimulating scientific research upon the brain and, on the other, with serving to perpetuate in new form the animism of the Greek medical men.

Summary

If there is a moral to this brief sketch of the origins of a science of psychology, it is this: From first to last the science has been haunted by the ghost-soul of primitive animism. From the time of Hippocrates, who housed it in the hollow ventricles, to phrenologists, who looked for "faculties" in the various subdivisions of the brain, men have sought to track it down in its lair. It has been driven from the heart, the lungs, the liver, the pineal gland as the physiologists have shown us the function of these separate organs. Even the spinal cord has lost its animistic properties as the researches of Sherrington and others have extended the discovery of Marshall Hall.

Nevertheless, in popular thought it is as effectively housed within the cranium as in the days of Hippocrates and Galen. Even the physiologist or neurologist sometimes falls a prey to the vocabulary of his times when he says that "mind appears to be as truly a cause of certain bodily actions as muscular contraction is a cause of bodily movement"—and then proceeds to identify mind and the activity of the brain.[1]

The problem which confronts us when we examine the central nervous system is a formidable one; the materials are extremely complex, and there is a vast amount of unexplored territory. But if animism is ever to be replaced by a science of psychology we must achieve a new conception of this ancient home of the soul.

[1] Herrick, C. J. *Neurological foundations of animal behavior*, p 302. New York: Holt, 1924.

CHAPTER II

THE CENTRAL NERVOUS SYSTEM AND BEHAVIOR

The Influence of Comparative Studies

Before Darwin, when it was believed that each animal form was produced in a special act of creation, it was possible to speculate as to whether animals had souls—and, if so, which animals, and what kind of souls. Only when the soul (or mind) was viewed as an immaculately conceived essence somehow *added* to the going organism could these questions have any meaning. As soon as the evolutionary view penetrated the psychological field and the mind of man was viewed as the outcome of the long struggle for survival the way was cleared for the complete rout of animism.

The "Mind" of the Simplest Animals.—The very phrase, "The mind of the simplest animals," with which Miss Washburn entitles her third chapter in *The animal mind*,[1] has consequences which carry one far beyond the animistic notions which have occupied our attention in the previous chapter. For the simplest animals are able to adjust to their environment without the intervention of a nervous system. While the protoplasm of which they are composed is not wholly undifferentiated, nevertheless, there is no brain; nor do there seem to be any "master tissues" to which one could assign a controlling, integrating function.

In the amoeba, for example (see Fig. 1), while there is some differentiation of structure in the different coats, or layers (plasmagel and plasmasol), there is a constant interchange of materials so that the portion of the protoplasm which at one moment lies near the surface as a semirigid elastic coating, at the next instant is found dissolved in the central fluid stream. There are no special structures which serve as rudimentary sense organs, or muscles, or nerves.

These lowly and comparatively undifferentiated creatures "seek"[2] (or at any rate respond positively to and ingest) food particles when

[1] Washburn, M. F. *The animal mind*, 4th ed. New York: Macmillan, 1936

[2] The animistic and figurative language into which we so easily lapse is a poor substitute for the more exact physicochemical account, but may serve as short-

"hungry," and show the indifference of satiety when they have fed. They avoid noxious stimuli (electrical, mechanical, and chemical) and they respond, moreover, as a whole, and achieve certain ends. There are even primitive forms of "choice" and "modification through experience" (which some writers have suggested as criteria of mind). As far as objectively observable functions go, there is no reason to deny mind to the amoeba if one is prepared to give a mind to the sponge, or starfish, or dog, or—for that matter—man.[1]

The Evolution of Behavior and the Differentiation of Structures.—The evolution of mind (and here "mind" must be used as the equivalent of behavior if we are to speak of anything that is observable) has occurred as animal forms have undergone differentiation and specialization. The functions which, in the most primitive forms, are mediated by undifferentiated protoplasm, often within a single cell, are divided among specialized structures in the higher forms. In the sponge muscular tissue is differentiated (see Fig. 2); in the Hydra neuromuscular cells, which are both sensitive and motile, appear; and in some polyps the sensory and motor functions are mediated by independent and differentiated cells (Fig. 3). When, in higher forms, the division of labor has been completed, a third type of tissue, connecting the sensitive cells with those that are highly motile, appears. Sensitivity, conductivity, and motility appeared in the simplest unicellular animals; and these functions reappear in the higher forms, with the difference that in the latter highly specialized tissues are the carriers. And in these higher forms differentiation has reached the point where one type of cell is helpless without the others. Without receptors, the mediating link has

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hand expressions for complex adjustments. Ideally, amoeboid "memory" will be traced to the persisting effects of physical stimuli, its "food seeking" described in terms of the sequence of physical changes induced by the combined effects of mechanical and chemical stimuli. The fact that the amoeba is "alive," that it "adjusts" to its environment, and displays "purposive" activities (on a primitive level, to be sure) in no way negates the possibility of a complete physical description of the processes.

[1] "We know not where consciousness begins in the animal world. We know where it surely resides—in ourselves; we know where it exists beyond a reasonable doubt—in those animals of structure resembling ours which rapidly adapt themselves to the lessons of experience. Beyond this point, for all we know, it may exist in simpler and simpler forms until we reach the very lowest of living beings." From Washburn, M. F. *The animal mind*, 4th ed., p. 32. New York: Macmillan, 1936. By permission of The Macmillan Company, publishers.

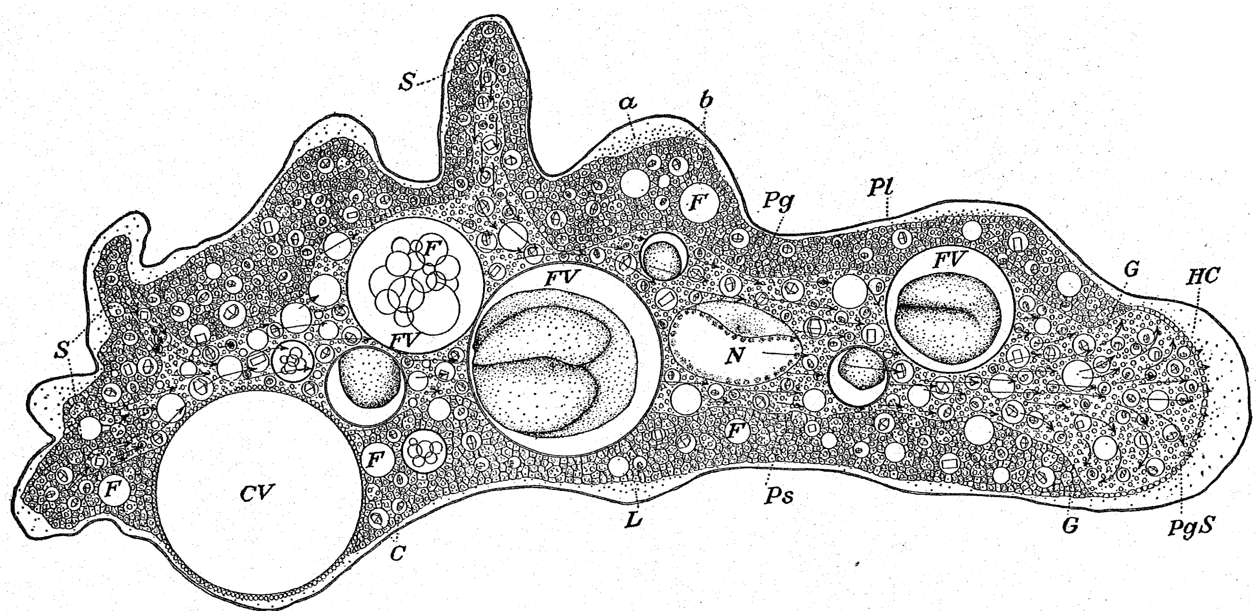

Fig. 1.—Schematic diagram of horizontal optical section of *Amoeba proteus*. *Ps*, plasmasol; *Pg*, plasmagel; *Pl*, plasmalemma; *HC*, hyaline cap; *PgS*, plasmagel sheet; *L*, liquid layer; *S*, region of solation; *G*, region of gelation; *N*, nucleus; *FV*, food vacuole; arrows, direction and relative rate of flow.

The forward movement of the amoeba is brought about by the forward streaming and gelation of the liquid plasmasol. Its gelation at the forward end (see arrows) forms an addition to the plasmagel tube; on the inner surface of the wrinkled, contracting, posterior end, plasmagel is going into solution. Locomotion begins when the external stimulus produces a local weakening of the plasmagel layer. (*From S. O. Mast. Structure, movement, locomotion and stimulation in Amoeba. J. Morphol. Physiol.*, 1925–1926, 41, 347–425. *By permission of the Wistar Institute of Anatomy and Biology.*)

nothing to transmit. Without effectors, the sensory and transmitting cells are unable to initiate any movements to or from a stimulus. And without the other two, the insensitive muscles could not react, save to relatively intense and local stimuli and in strictly limited patterns.

Behavior, then, has been a function of the entire organism from the simplest member of the protozoa to the higher vertebrates. The evolutionary process has complicated the structure and has introduced a division of labor between the various parts; but at no point in the evolutionary process is the student of comparative behavior moved to point to any structure and say, "Lo! Here mind begins." The threadlike cells which constitute the neural transmission system may serve to integrate distant parts and to communicate what would otherwise be a local disturbance to the other members of the body; but in no sense do the biological facts prompt one to invent a modern version of animism.

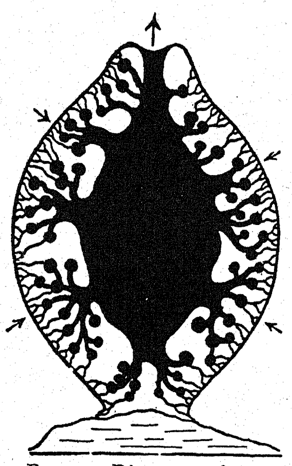

FIG. 2.—Diagram of canal system of sponge. Water enters through superficial pores (see arrows) and is discharged from the osculum at the top. The opening and closing of this osculum is the most obvious response of this sponge. (*After Haeckel. From G. H. Parker. The elementary nervous system, p. 25. Philadelphia: Lippincott, 1919. By permission of the publishers.*)

The Emergence of Specialized Relaying Tissues.—From the jellyfish, one of the simple forms wherein this specialized relaying tissue is definitely recognizable, to man there is a gradual increase in the amount of such tissue and a progressive cephalization in its architecture. The first nervous systems, for example, are a diffuse network of unbroken threads conducting impulses in some confusion; while the higher forms which replace them are synaptic systems (*i.e.*, systems in which the protoplasmic paths are broken into cellular units by gaps, or synapses).

The emergence of the synaptic system brings a new architecture and new functional possibilities. There is a marked improvement in integration which is made possible by the gathering together of masses of this tissue into a central mass (Fig. 5), so that an incoming impulse has to "take into account" all the other stimuli playing

upon the organism. (This figurative language should not lead us to endow the impulse with human qualities, but may serve as a short-hand expression for the facts of facilitation and inhibition which we must later consider in some detail.) "Cooperation" arises since

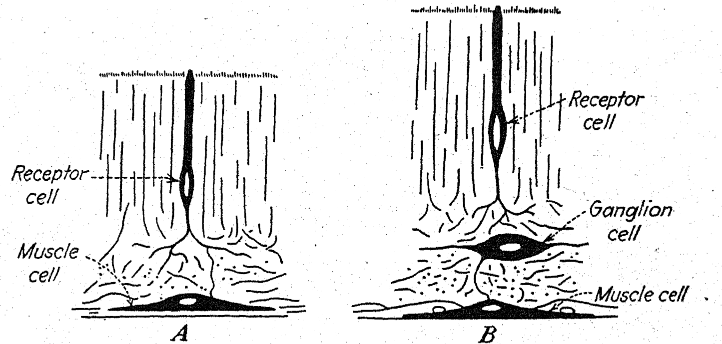

FIG. 3.—Diagrams of primitive reaction systems seen in sea anemones. *A*, a simple receptor-effector system with direct connections; *B*, a more complex system with ganglion cell interpolated between receptor and effector. (*From G. H. Parker. The elementary nervous system, pp.* 201–202. *Philadelphia: Lippincott,* 1919. *By permission of the publishers.*)

the action in a single muscle has to be "in the service of" all the rest of the organism; for the nerve fiber which stimulates it has had to pass through the "center" where the reports from every part of the

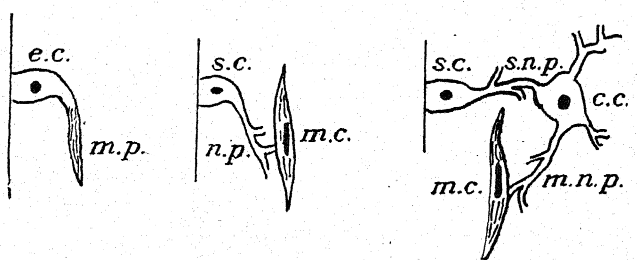

FIG. 4.—Schematic diagram illustrating the evolution of a transmission-integration system. *e.c.*, epithelial cell; *m.p.* muscular process; *s.c.*, sensory cell; *n.p.*, nerve process or fiber; *m.c.*, muscle cell; *s.n.p.*, sensory nerve process; *m.n.p.*, motor nerve process; *c.c.*, connecting cell. (*From E. H. Starling. Principles of human physiology, 6th ed. rev. by C. Lovatt Evans and H. Hartridge, p.* 232. *Philadelphia: Lea,* 1933. *By permission of the publishers.*)

periphery have an opportunity to further or hinder its passage. (Among the reports, as we shall see later, are reports from the rest of the musculature, so that it is as appropriate to speak of the center as being dominated by the musculature as to use the opposite, and

more usual, description.) Thus, the impulse which finally emerges to activate the muscle has received at least a "majority vote."

Does the Nervous System "Control" Behavior?—In one sense these "centers" do come to *control* behavior. While the nervous structures have been evolving, the distance receptors have also undergone elaboration and cephalization. In fact, a large portion of brain mass consists in the trunk lines running centralward from these important receptors, together with those cells which relay their "messages." Reporting, as they do, upon conditions at a distance from the organism, when these stimuli provide controlling cues for

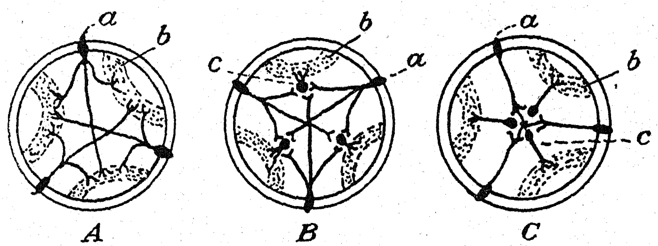

FIG. 5.—Diagram showing progressive centralization of nerve tissues. *A*, an ideal invertebrate with only cutaneous "sensory" neurons; *B*, invertebrate (*e.g.*, medusa) with sensory and motor neurons, but no central nervous system; *C*, invertebrate (*e.g.*, annelid) in which the motor neurons are concentrated in central ganglia; *a*, sensory neuron; *b*, muscle; *c*, motor neuron.

In *A* the effect of a stimulus spreads diffusely throughout the organism, affecting the adjacent effectors first. In *C* the stimulus passes first to the center, and before it issues to an effector, through *c*, it comes under the influence of the other sensory channels. The final response thus "takes into account" the totality of stimulating conditions, and a higher level of adjustment is made possible. (*From E. H. Starling, op. cit., p.* 233. *Philadelphia: Lea,* 1933. *By permission of the publishers.*)

the organism's responses the animal's behavior will take on the characteristics of "foresight." He will not wait for the physical impact of contiguous stimuli, but will adjust in anticipation of them.

In thus providing a mechanism which furthers the anticipatory and purposive behavior which so definitely characterizes the higher animal the nerve centers in some measure fulfill the animistic descriptions of an earlier physiology, though for vastly different reasons. We shall avoid the earlier errors if we remember that the nerve cells are relays and not points of initiation, and that they remain always under the further control of stimuli, an important number of which always come from the musculature itself.

Thus while it is true that the typically "higher" forms of activity, such as reasoning power, intelligence, and foresight, develop as we

pass up the animal scale from the diffuse nerve net of the jellyfish to the massive and intricate cerebrum of man, with its ten billion cells and well-developed forebrain, we need not put these powers or faculties into the nervous system, in the old fashion. The nervous system, in our view, can provide but part of the answer to the problem presented by these higher types of behavior; we should not confuse the part with the whole. If the nervous system is an important factor in the control of behavior, that is because it is the mechanism through which integrations are worked out. Though it mediates impulses it does not formulate purposes.

It is necessary to remind ourselves always that the activities we are interested in are, after all, activities of organisms; and in organisms the sense organs and the musculature are just as important for behavior as the nervous system.

Brain Weight and Intelligence.—The earliest comparative studies were misled by the faculty notion which psychology inherited from the phrenologists. Men were still inclined to locate the highest functions in the frontal lobes of the brain because of their high degree of development in man. Consequently, great importance was attached to mere cerebral mass as an index of the intelligence of a given species; but a brief consideration of the facts, such as are indicated in Table 1 disclosed such embarrassing relations that this notion could not be accepted without serious qualifications. As can be seen from the table, according to this basis of estimation the elephant and the whale would be classed as superior to man. Cuvier (1769–1832) proposed to overcome this difficulty by calculating the ratio between brain weight and body weight, recognizing that the

TABLE 1.—RELATION BETWEEN BRAIN WEIGHT AND BODY WEIGHT[1]

Animal	Brain weight, grams	Body weight, grams	Cuvier's ratio
Mouse	0 4	20	1:50
Cat	30	3,500	1:110
Monkey	100	5,000	1:50
Gorilla	400	90,000	1:250
Man	1,400	70,000	1:50
Elephant	5,000	2,500,000	1:500
Whale	7,000	70,000,000	1:10000

[1] The figures for brain weight and body weight were selected from a more extensive table of Warnecke. *J. Psychol. Neurol., Lpz*, 1908, 13, 355.

uncorrected weights gave a spurious advantage to the larger animal. But these values are no less embarrassing, and demand further explanation and correction. According to this latter method of calculation, shown in the fourth column (Cuvier's ratio) of the table, the mouse, no less than man, should be a philosopher. The fact remains, therefore, that neither the crude brain weight nor the brain-weight/body-weight ratio has any very clear meaning for the comparative study of behavior.

Least of all can we hope to find an index of intelligence in the brain weights of individual men and women. Table 2, showing the wide range of brain weights of eminent men, is suggestive; especially when we add that the larger group from which these samples of eminence were selected varies from 1,200 to 2,000 g., averaging 1,470 g. This last figure takes on additional meaning when we learn that it is but from "two to four per cent above the average for workhouse inmates";[1] and when we remember that the inmates are

TABLE 2.—SHOWING THE RANGE OF BRAIN WEIGHTS AMONG EMINENT MEN[1]

	Grams
Cuvier	1,830
Thackeray	1,658
Webster	1,518
Agassiz	1,495
DeMorgan	1,494
Gauss	1,492
Broca	1,484
Bertillon	1,398
Liebig	1,352

[1] Spitzka, E. A. A study of the brains of six eminent scientists. *Trans. Amer. Philos. Soc.*, 1907.

also inferior in weight and stature, and in other physiological indices, the degree of overlapping between the two groups, the eminent and the inmates, is certainly noteworthy. With the proper corrections for body size it is possible that the difference would disappear.[2]

[1] Ladd, G. T., and Woodworth, R. S. *Elements of physiological psychology.* New York: Scribner, 1911. European studies have reported median values for men ranging from 1,357 to 1,399, for women from 1,211 to 1,252.

[2] Some years ago newspaper dispatches told of the Cornell graduate who, in her will, asked that a post-mortem examination be made of her brain, and measurements taken. An ardent feminist, she was described as believing that the measurements for the brain weight of women—who have smaller brains than men—were inaccurate because they were obtained from the unemployed, the homeless, the friendless—who, she argued, were biologically inferior and not

Summary.—Our sketch of the comparative approach to the problem of the nervous system has served to remind us that behavior is an organic affair and that the nervous system is a transmission system and not a primary source or locus of purpose, foresight, etc. Its contribution is to be fully recognized; but the failure of all the mathematical indices of intelligence which have been exclusively preoccupied with neural development is an illustration of our main thesis. The gross variations between the species are found to have significance; but even these are subject to serious qualification. Physiological psychology is therefore driven to consider the total individual. The exclusive preoccupation with neural explanations which has characterized the psychology of the past may be regarded, therefore, as a survival of prescientific notions which looked for some special substance, some single locus, as a clue to the nature of the indwelling spirit of man.

The Reflex Arc

The Need for a Simplification of the Problem of Behavior.—In studying the reflex activities of the higher animals we seek to discover, under the simplest possible conditions, the essential mechanism which functions as the organism adjusts to its environment. When we deal with the totality of behavior, as when we attempt to describe problem solving or reasoning, we are almost forced to fall back upon such terms as purpose, insight, goal, intuition, effort, motive, deliberation, etc. These are the terms of everyday discourse, and—after a fashion—we understand them. But between the presentation of the problem (stimulus) and the issue of the solution (response) there is an enormous gap. Subjectively, as we

representative. Therefore, in her desire to raise the score for her side she made the offer to the medical school—hoping, no doubt, that others might emulate her example. Alas for her zeal! A woman of attainment though she was, her brain weight fell below the average previously reported for her sex. Nor is there anything in this fact which should surprise one, when the animistic premises of phrenology are once abandoned.

Similar mistaken enthusiasm must have misled the Congress of the United States when, in recent session, it appropriated a sum of money for one Dr. Arthur MacDonald of Washington, D.C. Dr. MacDonald is also a modern disciple of Gall and Spurzheim and his measurements of Congressional heads led him to report that "it takes more brains to get into the Senate than the House." Other illuminating items appear in his full report, printed in the *Congressional Record* for 1932.

experience it in ourselves, the interval may be filled with "flashes of insight," forebodings, images and recollections, etc.; but these terms do not lend themselves easily to analysis, and a century and more of peering directly into the mind has not made clear the structure of the events which intervene between stimulus and response. And so it is that the mental event, which we vaguely place between the stimulus and the response, is more or less a terra incognita.

Moreover, when, prompted by the advance in anatomical and physiological knowledge, we pursue another method and attempt to treat the intervening events objectively we are confronted with an almost equally baffling problem. If we treat the nervous system as a huge central exchange of an automatic telephone system, its sheer complexity staggers our imagination. The main switchboard, with its 9–10 billions of cells, has possibilities of complication and patterning which rival the figures of astronomical calculation. We have but taken the first steps in planting our instruments of observation upon the path of these patterns. When, for example, we learn that as we ponder a proposed course of action there are "action currents"[1] in the nerves of the brain we have made a very slight advance indeed. The photographic record of the electrical changes is of such complexity that we are still far away from an understanding of the physical basis of those thoughts and purposes which we know subjectively.[2]

The failure of introspection, on the one hand, and the baffling complexity of cerebral physiology, on the other, drive us to seek a simpler unit, an isolated mechanism along the elements of which we may plant our instruments of observation.

Typical Reflex Activities.—First, as to the phenomena. A slight electrical shock applied to the cheek of a human subject, just beneath the eye, will produce a spasmodic reflex closure of the lid. Similarly, if a subject is seated and his knee supported so that the lower leg hangs freely, a light, sharp blow delivered just below the kneecap

[1] Minute changes in electrical potential at the surface of a nerve fiber may be amplified and recorded photographically. The amplified currents are made to activate a string galvanometer whose tiny mirror reflects a beam of light upon a rapidly moving film.

[2] The mass of electrical changes is not unlike the confused mass of vibrations which we can sense as touch when we place our finger lightly over the vibrating disk in a telephone receiver. Just as we are unable so to read the pattern of spoken words, so the electrical record of brain action has so far failed to yield anything like the "pattern" of thought.

will elicit a reflex jerk in the muscle of the leg (quadriceps) and a resultant outward thrust of the foot. Or, again, a light touch in the palm of the week-old infant will initiate a reflex closure of its fingers.

In the examples given the responses follow immediately upon receipt of the stimulus and, while there are minor variations, they may be repeated again and again, mechanically, monotonously. They require no warning, no preparatory "set," no conscious effort. In fact, their analogues are found in the spinal animal. Thus, in a

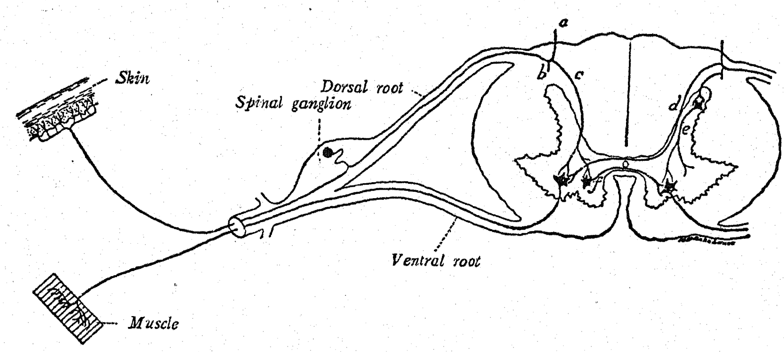

FIG. 6.—Diagrammatic section of the spinal cord and a spinal nerve. The impulse which is aroused when the skin is stimulated travels centralward by means of the dorsal root and enters the cord at the back. The T-shaped cell body of this afferent fiber is shown within the spinal ganglion. Traversing the cord, this afferent fiber penetrates the central mass of gray and excites a motor neuron which leaves the cord by the ventral root. At the end of the motor fiber its end-brush is shown penetrating a striped muscle. Internuncial neurons are shown at *o*, and these make possible the arousal of responses on the side of the body opposite the point of stimulation. (*From S. W. Ranson. Anatomy of the nervous system, 5th ed., p. 53. Philadelphia: Saunders, 1935. By permission of the publishers.*)

decapitated frog, a bit of blotting paper moistened with weak acid and laid upon the skin will elicit a "defensive" reflex which appears calculated to remove the irritant. Or, in the decerebrate dog, a mechanical stimulus (rubbing, scratching) applied to the skin anywhere within a saddle-shaped area of the back will elicit a scratch reflex in the flexor muscles of the leg of the same side and an extensor thrust (posture-supporting) of the opposite side.

The Responding Mechanisms.—The mechanism of the reflex, schematized in Fig. 6, requires at least two cells. The sensory cell, with its cell body lying outside of and dorsal to the spinal cord, sends one of its branches to the surface of the body, and one into the central gray portion of the cord. At this point it touches the second cell, which sends a long process ventralward to the muscle.

The synaptic junction, or point of contact, between the two cells is represented at *O*. It is needless to point out that such a scheme, composed as it is of but two isolated fibers, has no counterpart in nature. The bundles which issue from the ventral spinal cord as one of the ventral roots contain in the neighborhood of 200,000 fibers; the dorsal roots contain about 630,000.[1]

Even the architecture of the single cell is difficult to schematize. Figure 7, a conventional representation of a motor cell, is again a simplification. The branching dendrite and the end brush may have a complexity such as is shown in the purkinje cell (Fig. 8). Microscopic examination of the cell bodies within the gray matter shows that as many as a hundred terminal disks of end-brush fibers may

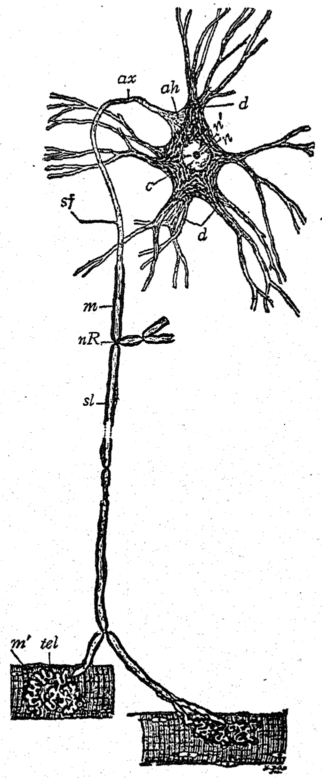

FIG. 7.

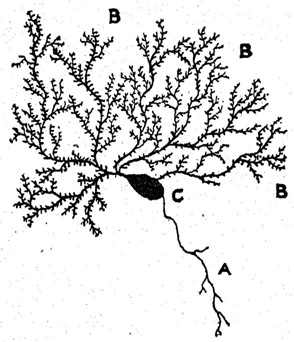

FIG. 8.

FIG. 7.—Diagram of a motor neuron. A typical cell from the ventral gray of the spinal cord. *ax*, axon; *d*, dendrites; *m*, myelin (medullary sheath); *m'*, striated muscle fiber; *sf*, collateral branch; *tel*, motor end plate. Axon, dendrites, end plate, collaterals, cell body, all go to make up a single neuron. (*From C. J. Herrick. Introduction to neurology, p.* 41. *Philadelphia: Saunders,* 1921. *By permission of the publishers.*)

FIG. 8.—Neuron from the cerebellum. (*From S. I. Franz and Kate Gordon. Psychology, p.* 197.)

end upon a single cell body. Thus a single motor cell becomes the final common path for impulses from scores of incoming pathways.

[1] Creed, R. S., Denny-Brown, D., Eccles, J. C., Liddell, E. G. T., and Sherrington, C. S. *Reflex activity of the spinal cord*, p. 9. Oxford: The Clarendon Press, 1932.

The incoming sensory fibers distribute their energy over many motor cells. The synapse, represented in Fig. 6 as a single junction between cells, is in reality an extremely complicated affair, the simplest junction being composed of numerous minute patches underneath the separate terminal disks. Finally, the axon of the motor nerve divides as it reaches a given muscle, and its branches will innervate as many as a hundred separate muscle fibers.[1] When we remember that stimulation rarely, if ever, affects a single afferent neuron, the degree of simplification in our diagram is apparent.

The Development of Behavior and the Growth of Reflex Structures.—As the neural arcs are completed, the behavior of the individual shows corresponding changes. This has been neatly demonstrated in a study by G. E. Coghill. Working with the developing Amblystoma he was able to show that the serial development of swimming, walking, and eating activities was dependent upon a parallel development of neural connections. For example, before the animal can swim it responds to a stimulus on the left side of the head with a coiling movement, produced by a contraction of all the muscles on the opposite side. Anatomical studies showed that the requisite paths had been completed. When the sinuous swimming movement appeared, this unilateral wave of contraction of the coil was interrupted and, figuratively, reflected back and forth along the animal, so that the contraction of the first muscle segment appeared to initiate the contraction of the next segment on the opposite side, and alternating waves of contraction succeeded one another. Again, anatomical studies revealed that the requisite commissural paths had developed.

Thus we get a glimpse of a progressive elaboration of behavior, an elaboration and development determined by the development of connecting structures. Coghill observes: "Growth of the terminals of axons and dendrites through microscopic dimensions is sufficient to have profound effect in behavior. This we have demonstrated in the first lecture in a vertebrate of such primitive form as Amblystoma, which, by the growth of terminals of nerve cells over a distance of less than one one-hundredth of a millimeter, transforms itself from an animal that must lie helpless where chance places it

[1] What we call a muscle has been shown to consist of tens of thousands of muscle fibers, arranged more or less in parallel and attached at one end to a tendon. The hundred-odd fibers innervated by a single motor axon is referred to as a "motor unit."

into one that can explore its environment in response to impulses from within or stimulation from without."[1]

Development as Progressive Differentiation.—Coghill also emphasizes the fact that the progress of development, in Amblystoma at any rate, is one of progressive differentiation and individuation of total responses rather than the gradual addition of reflex units. That is, the movements of the limb are originally a part of a massive contraction of the trunk, and movements of an arm precede the independent action of a forelimb or hand. Coghill is inclined to generalize upon these developmental facts and warns us against any attempt to construct a picture of organic behavior out of the *sum* of isolated reflexes, conceived as "atoms" of behavior—more or less isolated. His study indicates that the reflexes are not the precursors of the main movements; on the contrary rather, they are subordinate to the "over-all" patterns from first to last. Genetically, he argues, the local reflex emerges from a matrix to which it has been subordinated at every stage of its growth; and although it attains a measure of freedom to act independently it is in no sense the primordial unit out of which the total patterns of action are constituted. In his figurative language, "The central government, so to speak, establishes its sovereignty over the rising community before that community has acquired a central organization of its own, and subsequently grants to its subject more or less autonomy as time goes on."

Students of behavior owe a great debt to Coghill for the pioneering work he has done in establishing correlations between structural development and behavior. It is possible that this type of study will throw a great deal of light upon the development of behavior in the child; for it has long been noted that a similar rule of development holds. The massive coordinations of trunk and limbs lead the finer movements of the hand, for example; and the delicate and independent action of the fingers follows a more massive action of the hand.

We should hesitate, however, before making a complete generalization of one set of results. Later observations by Windle,[2] on the

[1] From Coghill, G. E. *Anatomy and the problem of behavior*, p. 84. New York: Macmillan, 1929. Reprinted by permission of The Macmillan Company, publishers.

[2] Windle, W. F. Correlation between the development of local reflexes and reflex arcs in the spinal cord of cat embryos. *J. comp. Neurol.*, 1934, 59, 487–503. This investigator concludes: "Morphologically and physiologically, there is no

developing embryo of the cat, give clear evidence that the local reflex may lead on occasion. We shall return to a discussion of the problem in a later chapter, where we shall treat the problem of development in greater detail.

Summary.—1. We have seen that the reflex path is a protoplasmic transmission line of exceeding complexity. A single afferent fiber, as it divides and subdivides, may activate different levels of the cord and both halves of the body. With the terminal arborizations of the fibers activating many relays, an ever-widening path for the spread of impulses is provided. Similarly, the examination of the minute structures of the cord suggests that a single motor cell presents a funnellike point of convergence for a whole network lying centralward.

2. Embryologically, the path arises from cells situated along the neural tube. The growing fibers, before they are able to function in the reflex arcs, are under the influence of extrinsic factors. As the more mature cells begin to function they act upon the less mature cells, shaping the final stages of their development. The very course of their development prevents us, therefore, from treating the reflex as an isolated atom of behavior.

3. As paths mature, behavior undergoes development. The rule is: from trunk action to limb action, from limb to hand, etc. That is to say, the isolated reflex represents a later stage of differentiation and follows rather than precedes total activities. As in its development it has always been subject to a matrix of forces, so in its final form it should be expected to show this same subordination.

The Nature of the Nerve Impulse

Before attempting a more detailed description of reflex action let us attempt a brief summary of the characteristics of the nerve impulse.

1. In medullated nerves of the mammal it travels at *ca.* 100 m. per second. In nonmedullated nerves (*e.g.*, in the autonomic nervous system) it travels at *ca.* 1 m. per second.[1]

evidence that the concept of a gradually expanding total pattern completely integrated from the beginning can be applied to the first leg reflexes of the cat embryo."

[1] These rates vary with temperature but are independent of the strength of the stimulus. Hill, A. V. *Chemical wave transmission in nerve.* Cambridge, Engl.: Cambridge Univ. Press, 1932.

2. The passage of energy does not "exhaust" or seriously deplete the energy of the fiber, with the result that nerve fibers may continue to conduct impulses for hours without giving evidence of "fatigue." (This statement does not hold if the oxygen supply is limited, and does not apply to nonmedullated fibers.)[1]

3. However, there is a brief "absolute refractory period" immediately following the passage of a stimulus. During this period the nerve does not respond to stimulation. In frog's nerve at 20°C. this period is *ca.* 0.001 sec. Increasing temperature to 30°C. the value falls to *ca.* 0.0003 whereas at 10°C. it is 0.003.

4. The impulse is found to consist of a train of waves. Although the physical change acting as stimulating agent may be constant (*e.g.*, pressure), nerve action proves to be intermittent. The number of waves and their rate of succession depends upon the intensity of the stimulus, although an upper limit upon the rate of succession will be imposed by the value of the refractory period. Frequencies between 10 and 100 are common, but values as high as 1,000 waves per second have been reported.[2]

5. Immediately following the "absolute refractory period" there is a "relative refractory period" during which a stronger stimulus is required to start an impulse. Impulses falling within this period are also of smaller magnitude. It is also possible for an ineffective stimulus—too weak to arouse a response—to alter subsequent excitability. Its immediate effect is to increase the effectiveness of a succeeding stimulus.

6. Oxygen is consumed in small amounts, carbon dioxide is given off, and heat is set free, although the values for the heat are so small that until recent years they defied measurement. The heat production occurs both during and following the passage of an impulse. The latter may last as long as an hour.[3]

7. When physiologists speak of the speed of a nerve impulse they commonly refer to a wave of negative potential which travels along the surface of the fiber, for it was in terms of such a moving "minus charge" that all the early measurements were made. It is commonly asserted that such an impulse obeys the "all-or-none law," for the

[1] Starling, E. H. *Principles of human physiology*, 5th ed., p. 207. Ed. and rev. by C. Lovatt Evans. Philadelphia: Lea, 1930.

[2] Erlanger, Jos., and Gasser, H. S. *Electrical signs of nervous activity.* Philadelphia: Univ. of Pennsylvania Press, 1937.

[3] Hill, *op. cit.*, p. 22.

magnitude of the electrical charge did not vary with the energy of the exciting stimulus. With stronger stimuli more fibers may be activated, but the single fiber responds up to the maximum permitted by its physiological state at the moment. Although some of the characteristics described above serve to qualify the all-or-none character of the impulse, the phenomena of nerve action occur very much as though the passage of an impulse discharged a quantity of explosive energy. Its action is like that of a trigger; pulling the trigger harder (above a certain minimum) releases no greater explosion.

Conduction Rates and Reflex Reaction Time

1. **Reaction Time.**—When recording instruments are applied to the reacting muscles of a spinal animal, it is found that there is a lapse of time (latent period) between the application of the stimulus and the beginning of the curve of contraction. A portion of this time is consumed by the passage of the impulse from the stimulated point on the afferent nerve up to the cord, and another portion by the passage over the efferent axon back to the muscle. But the fastest reflexes have latencies which are too great to be wholly accounted for in this fashion, unless conduction rates within the center are much slower.[1]

This delay in the central portion of the conduction path has contributed an important share to the concept of "synaptic resistance." The fixation of habits, wherein our actions become more rapid and automatic, is often referred to as an "overcoming" of synaptic resistance. The objective fact that impulses pass more and more readily through the central area is clear; but the experimental evidence provides an exceedingly sketchy picture of the precise nature of the "delaying" process. We know merely that those reactions in which the impulse has to cross the cord, or to move to distant levels, show longer latencies. When we pass from the reflex to the voluntary responses of the human subject, where presumably the longest and most complex paths are involved, we find that the shortest reactions demand approximately 100 millisec.

The reflexes of the spinal animal are by no means invariable. They vary with the intensity of stimulation, the physical state of the muscle involved; and they are affected by circulatory changes

[1] Cf., *e.g.*, the value of *ca.* 40 millisec., for the eyewink, published in the studies of Hilgard, Schlosberg, *et al.*

and by drugs. And the general rule is that where more complex mechanisms are involved the performance is also more variable.

Compound Reflexes

2. Responses to More than One Stimulus. *a. Convergence, Summation, Facilitation.*—If stimuli at the rate of 50 per second are applied to an afferent nerve which arouses the flexor reflex (the flexors, for example, are involved in lifting the leg or in bringing it forward), and the intensity of the stimulus gradually increased, the muscle contraction will increase up to a certain maximum beyond which further increase in stimulation will yield no increment. We might assume that at this point all the fibers of the muscle are thrown into action. That this is *not* the case is shown by two facts: (1) a similar procedure in which the stimulus is applied to the motor nerve directly produces a much larger maximum response and (2) similar procedures, using other afferent nerves (which also produce contraction within the same muscle), yield varying maximal values.

Thus, stimulation of one afferent nerve may yield a maximum response of 800 g., of another a response of 1,240 g., etc. Neither nerve, taken alone, produces the maximum tension (2,160 g.) produced by stimulation of the motor nerve. On the other hand, the sum of the responses achieved by, say, ten different channels will far exceed the maximum of the direct motor stimulus.[1] These facts give a demonstration of the outcome of that convergence and distribution of nerve impulses which the structures of the center make possible.

If we let the fingers of our two hands represent the branching end brushes of two incoming sensory fibers we may represent some of the facts of convergence and facilitation rather easily, particularly if we allow some but not all of the fingers to overlap. Now, each hand may be thought of as activating five motor elements; but their sum is not equivalent to ten. We can see also that when each of the two sensory fibers bears impulses too weak to act upon the motor nerve their joint effect (summated at the center) may be sufficient to produce a response. Thus it is—at a higher level—that the moving lips, facial expression, gestures, and the sound of the voice are jointly able to arouse comprehension when the elements given separately are individually unable to arouse response.

[1] The figures quoted above are discussed on p. 24 of *Reflex activity of the spinal cord*, Creed *et al.*, *op. cit.*

The clinician "facilitates" the knee jerk of his patient by asking him to clench his fists prior to the blow on the tendon. A group of "doubting Thomases" bombarding one with questions and critical objections may shake the foundations of belief—foundations that might withstand the opposition of a single member of the group. Similarly, the mildly annoying or irritating stimulus may become, on repetition, excruciatingly painful, so that "something has to be done about it."

b. Inhibition.—A second stimulus does not always increase the size of the reflex response; it may, in fact, inhibit the response

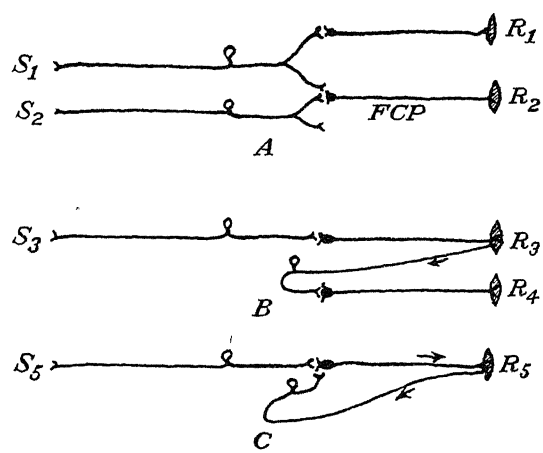

FIG. 9.—Simultaneous and successive combinations of responses. *A*. Impulses set up at S_1 are distributed to the two effectors, R_1 and R_2. *FCP*, the final common path for impulses arising at S_1 and S_2, illustrates the mechanism of convergence, or facilitation.

B. Chain reflex in which a first reaction at R_3 gives rise to afferent impulses, which in turn arouse R_4.

C. Reflex circuit in which afferent impulses set up by the response R_5 serve to support and maintain a continuing reaction in the same effector.

entirely. On a higher level we are all familiar with instances of inhibition. An absorbing interest may make us impervious to the sights and sounds around us, the infantryman in the attack may be unaware of his wounds, etc. One process has inhibited another. Under the influence of fatigue, or of alcohol, a man may so lose his normal inhibitions that indiscreet remarks and actions ordinarily checked by his dominant, socially directed attitudes, find free expression. And we describe the shy, seclusive, timid individual as "too inhibited" or "too repressed." His potentialities for action are

never freely released, something seems to hold him back. Similarly, there are times when memories which at other occasions function properly, and which we are sure that we possess, fail us entirely. Every act of skill, every persistent search for an objective, involves inhibition; in fact, this clearing of the right of way, this removal of interfering and distracting actions, is an essential phase of any successful and efficient type of response.

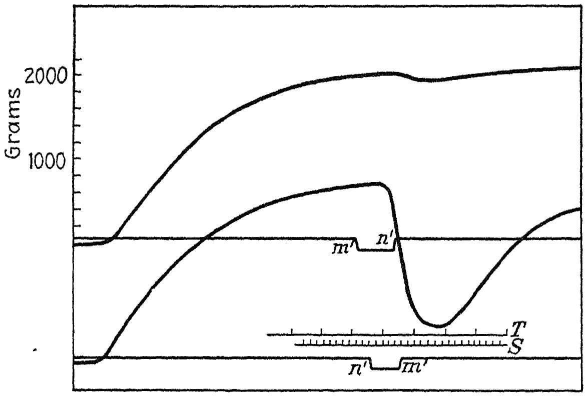

FIG. 10.—Curves illustrating the contrast between inhibition and mere cessation of stimulation. The two curves are recorded from the vasto-crureus muscle of the decerebrate cat. A reflex tetanus is produced by break shocks at 48 per second, the same intensities being used for both reflexes. In the upper curve, a lapse of six consecutive stimuli (indicated at m' and n') has produced merely a shallow notch (a drop of 100 grams in the tension plateau of 1,900 grams). In the lower curve there is no lapse of the excitatory stimuli, but an inter-current inhibitory stimulus of half this period (*i.e.*, for a period corresponding to the delivery of three consecutive stimuli to the contralateral afferent nerve) produces a marked drop in the curve of response (from 1,900 grams of tension to 500 grams in 0.06 second). *S*, break shocks at 48 per second; *T*, time in tenths of a second. (*From E. G. T. Liddell and Sir Charles Sherrington. Stimulus rhythm in reflex tetanic contraction. Proc. roy. Soc.*, 1923, *B* 95, 142–156. *By permission of the Royal Society.*)

The explanation of these facts is neither simple nor wholly agreed upon. It will not do to turn this function over to a directing and controlling mind (the anima), nor have we proceeded much further when we describe the function as carried out (however vaguely) by the nervous system. We shall make a beginning in understanding if we keep in mind that it is the interfering stimulus (and its reaction system) which does the displacing, inhibiting.

That it is more than a mere cessation of peripheral stimulation can be clearly demonstrated. Compare, for example, the sharp drop in the curve of response in Fig. 10, when an inhibitory

stimulus is applied, with the slight gradual drop produced when the stimulating break shocks are interrupted for a brief interval. (In this case the period of interruption is twice as long as the period during which the inhibitory stimulus acted.)

In addition to showing the difference between inhibition and mere cessation of afferent stimuli, Fig. 10 gives an instance of another phenomenon, called *after discharge.* No matter how brief the stimulus to an afferent sensory ending may be, the reflex response is never a single simultaneous explosion of all the fibers of the muscle—and then abrupt cessation. The single volley is "dragged out" into a train of stimulations as it passes through the reflex center. Bifurcating paths, imposing roundabout relays, and different conduction rates may account for some of the temporal spread of impulses. This after discharge may, as in the flexor reflex, prolong the response by as much as 100 millisec.[1] The sharp drop in the "inhibitory" curve is therefore quite different from the usual trailing off of a response following cessation of stimulation. The inhibitory stimulus puts an abrupt end to the after discharge. The muscle fibers seem to be removed from the influence of the motor center as abruptly as though a switch had been pulled. Numerous theories have been advanced to account for this phenomenon, and in recent years three have been discussed: the interference theory, the chemical theory, and the explanation in terms of chronaxie.

1. THE INTERFERENCE THEORY.—According to this theory, inhibition is the result of the "crowding" of impulses, crowding so great that the conductor becomes choked. Nerves, like muscles, require a certain period of time in which to recover their excitability after they have responded. Although, in the case of nerve fibers, this refractory period is very short, it is possible to crowd the stimuli so rapidly that reaction is decreased, or checked altogether. The stimuli which fall within the refractory period not only fail to arouse the usual reaction; they also prevent recovery, and so keep the conductor continually depressed. Thus the second (and inhibitory) stimulus might be thought of as achieving its effect through the crowding it produces as it converges upon neurons already conducting impulses. According to this view, it is not necessary to assume any special type of impulse, nor any properties of central tissues not found at the periphery.

[1] The after discharge holds also for de-afferented muscles. See Creed *et al.* for discussion.

2. The Chemical Theory.—Sherrington and others have proposed a chemical theory of inhibition. Analogous processes occurring in other structures have suggested that the inhibitory fibers set up an inhibitory state ("central inhibitory state," or, as it is frequently written, c.i.s.) which neutralizes any excitation process going on at the moment and renders the motor neuron temporarily "refractory." The fact that a single inhibitory stimulus (break shock), delivered 100 millisec. *before* an excitatory stimulus (also break shock), will render the latter ineffective argues against the "interference theory," especially when it is remembered that neither stimulus sets up a prolonged volley. And, on the other hand, this continued depressant effect, sometimes lasting from 1 to 4 seconds after the stimulus, is easily accounted for on the chemical basis. Moreover, evidence for such chemical "inhibitors" is not wanting. It has been found for example, that when the action of a frog's heart is inhibited by stimulation of the vagus nerve, and the liquids bathing the preparation are circulated through a second heart, the latter—although not similarly stimulated—is inhibited.[1]

3. The Chronaxie Theory.—A third theory, proposed by Lapicque, asserts that the permeability of a path is a matter of *tuning* and not of physical contact. Two radio sets, side by side, are both "bathed" with countless waves; but each will react to the one frequency to which it is tuned. Similarly, Lapicque would say that the afferent stimulus can elicit a response only in those motor neurons which are appropriately tuned. The anatomical paths are much more diffuse than the functional possibilities. Under special conditions (*e.g.*, under the effect of strychnine) this fact is demonstrated; for with proper dosage a single stimulus will evoke simultaneous contraction in nearly all the skeletal muscles of the body. Since such general contraction involves both flexors and extensors, the spasm of contraction results in rigidity and tremor, instead of movement, and we can see at once how inadequate the "geometrical" conception of nerve connections is.

[1] Fulton, J. F. *Muscular contraction and the reflex control of movement.* Baltimore: Williams & Wilkins, 1926. An excellent summary of the "chemical" theory of excitation and inhibition is contained in Chaps. 13 and 14, pp. 313–363 See, too, Forbes, Alexander. *Handbook of experimental psychology*, Chap. 3, The Mechanism of Reaction, pp. 155–197. Ed. by C. Murchison. Worcester: Clark Univ. Press, 1934.

Turning to the temporal characteristics of the stimulus, Lapicque was able to demonstrate their importance. Figure 11 shows a curve which represents a relationship between the intensity and the duration of the exciting stimulus. In this one observes that as the intensity of the stimulating current increases the duration of the stimulus necessary to elicit a response falls. A minimal constant current of indefinite duration is called the *rheobase*. In order to secure measurable values for "duration," Lapicque arbitrarily chose to measure the time required by a current exactly twice the rheobase. The measures of "excitation time" thus secured varied from 0.2 millisec. (mammalian nerve) to 100 millisec. (smooth muscle), showing that there are both "rapid" and "slow" tissues. These differences, relatively permanent and depending upon the nature of the tissue, upon its molecular structure and condition, he termed *constitutional chronaxie*.

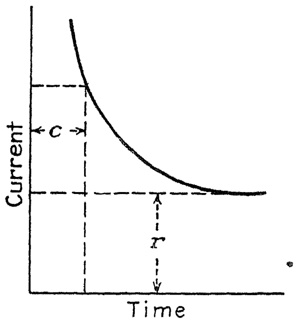

FIG. 11.—Curve correlating duration with strength of a constant current which barely suffices to excite. Abscissas, duration; ordinates, strength of current. The value *r* represents the minimal voltage of a constant current of indefinite duration (rheobase). The value *c* is the least duration at which a voltage double the rheobase will excite the tissue. *(From a curve presented in Alexander Forbes's article, The Mechanism of Reaction. Handbook of experimental psychology, p. 164. Ed. by C. Murchison. Worcester: Clark Univ. Press, 1934. By permission of the publishers.)*

With this much established, Lapicque turned to the investigation of some of the simplest cases of inhibition. Curare, the Indian arrow poison, produces paralysis, completely blocking the passage of impulses. Moreover, this inhibition is found in a nerve-muscle preparation where there is only the muscle and a fragment of the motor nerve, and no question of centers can arise. Further, although the preparation does not respond, both nerve and muscle are individually excitable; the neuromuscular junction would seem to be the location of the "block." Lapicque, pursuing his measurements of chronaxie, discovered an interesting fact. Whereas before poisoning the chronaxie values for nerve and muscle had been approximately the same, afterward the chronaxie of the muscle had been doubled.

Inhibition is here seen to occur when the chronaxies differ; conduction, when they are similar; when the difference mounts to the point where the ratio is 2:1 conduction ceases. For some time this

curare effect had been attributed to changes in the end plate of the motor nerve, induced by the drug; and although anatomists have shown the phantom character of any such end plate, until Lapicque's demonstration was made some sort of chemical substance at the myoneural junction has had to do duty. It is quite possible, argued Lapicque, that the synaptic resistance and the c.e.s. (central excitatory state) and c.i.s. of the Sherrington school will disappear before a similar analysis of central inhibition.

Let us apply the chronaxie conception to two instances. Consider, first, the ordinary flexion reflex in which a limb is withdrawn from a painful stimulus. Why doesn't the stimulus flood all the motor paths of the member (both flexors and extensors)? The effect of strychnine shows that these paths are anatomically present. The answer, in terms of the chronaxie theory, lies in the discovery that under ordinary conditions the chronaxies of flexors and extensors bear the ratio of 1:2, whereas under strychnine they are equated.

Or, take the case of the spinal frog whose foot is extended. Under this condition, when the foot is pinched *withdrawal* occurs; but when the leg is flexed the same stimulus produces *extension*. We need not turn to any anatomical switching of connections for an explanation of this shift in response if the observations of Lapicque are verified. He found that the shift in position of the member altered the chronaxies of its muscles, the changing tension affecting proprioceptive nerves which carry impulses from the muscle. The latter in turn alter the chronaxies of the motor fibres leading to the muscle. There is thus a "retuning" of the whole circuit and a subordination of the conduction system to the conditions which exist at the periphery.

The existence of such a mechanism introduces a neat reversal within the hierarchy of bodily tissues. The nerves, hitherto referred to in both popular thought and physiological treatise as the *controlling* tissues, are here seen to be regulated by the muscles. These effectors, when preoccupied, seem to send "do not disturb" signals to the center; with the result that incoming signals are shunted down other paths. Not the center, not the peripheral stimulus, but the *posture* serves as the regulator.

The Reflex Circuit.—The facts which have just been cited call for a revision and extension of our conception of the reflex arc. Hitherto we have been concerned solely with stimuli passing to the muscles. Moreover, it is a well-established fact that stimulation

of the motor nerve will not spread back across the synaptic junction into the central nervous system. The disturbance on the motor nerve can travel in either direction on the motor fiber itself; but the synapse is valvelike in its action, permitting impulses to pass from the sensory to the motor fibers, but effectively blocking reverse action. The muscle which is to exert a controlling influence upon the transmission system must therefore act through an independent sensory path. Figure 9*C* shows such a return path, with the sensory cell body located in the dorsal ganglion along with the rest of the afferent cells.

When these return paths are severed, reflex behavior is profoundly altered; contractions become jerky, explosive, and instead of being able to hold postures and execute graceful movements the subject flings about his members with the flaillike movements of a mechanical toy. This condition is seen in the human subject in *tabes dorsalis* (locomotor ataxia), a disease which cuts off the afferent impressions[1] from the muscles and is characterized by a more or less complete loss of control of the extremities. The muscles do not lose their power to contract, but there is a loss of "tone" and a characteristic exaggerated gait. The leg is raised too high in stepping and the foot is brought down to the ground with a stamp. With feet together and eyes closed the patient cannot maintain his balance, and in the later stages of the disease, according to Starling,[2] "attempts to walk simply give rise to a profusion of disordered movements, the legs being thrown in all directions with the patient's efforts, but with no effective result."

These observations indicate the presence of a reflex element in all our activities. No act of "will," no conscious control, can replace the reflex adjustments through which the muscles regulate the course of their own contraction. The persistent and expectant posture maintained by the runner "on the mark" would be impossible were it not for the mechanism of the reflex circuit; and instead of the normal smooth flow of skilled acts, human behavior would resemble that of the jumping jack.

The Chain Reflex.—The proprioceptive return path may innervate other muscle groups. Thus in Fig. 9*B* the proprioceptive impulses initiated by R_3 may activate R_4, and by a similar path R_4

[1] The spinal cord lesions which produce the sensory loss are caused by the Spirochaeta pallida of syphilis.

[2] Starling, *op. cit.*, p. 272.

will evoke R_5, etc. Thus, in swallowing, the successive contraction of the muscle rings of the esophagus depends upon such muscle-to-muscle reflex pathways. Likewise the crawling of the earthworm and the walking of the quadruped show the same muscle-to-muscle relay.

Reciprocal Innervation.—In the act of walking the chained character of the response is complicated by a further relationship. The free and unimpeded swing of a limb about a joint demands more than the stimulation of the muscles on one side of the member. Even the "resting" muscle shows some tone and is not completely limp; and such partial contractions would impede our movements, give them a stiff and rigid character.[1] In slow movements this "antagonistic" action is necessary (though as contraction mounts in one muscle its antagonist gives way in reciprocal fashion); but in movements which are to attain any great speed the antagonist is inhibited entirely.

Thus, in a simple to-and-fro movement (*e.g.*, in rapid tapping) flexors and extensors will alternate in "throwing" and "catching" the member; but they do not oppose one another, save at the joint farther back where the member which supports the movement is fixated.[2]

If the decerebrate dog is supported in a "sling" so that his legs hang unsupported, pinching the pad of one hind foot will initiate changes in four groups of muscles:

1. Flexors of the stimulated limb contract.
2. Extensors of the stimulated limb relax.
3. Extensors of the opposite limb contract.
4. Flexors of the opposite limb relax.

In this arrangement there is a double reciprocal innervation: the forward movement and lifting of one leg is accompanied by an extensor thrust on the opposite side, and in each leg the action of one group (flexors on the right, extensors on the left) is matched by the relaxation of its antagonists (extensors on the right, flexors on the left). A series of such "steps" may be produced by continuous stimulation,

[1] Where, for example, the weight of a limb is allowed passively to stretch its flexor muscles, and the extensor muscles are detached so that their shortening can produce no limb movement, an extensor stimulus will be accompanied by a drop in the limb. The drop demonstrates the loss of the partial contraction, or tone, which even the resting muscle has.

[2] See, *e.g.*, the study of Stetson, R. H., and Bouman, H. D. The coordination of simple skilled movement. *Arch. néerl. Physiol.*, 1935, 20, pp. 177–254.

one step following another in rhythmic succession, with little or no interference between the opposing muscles (see Fig. 12).

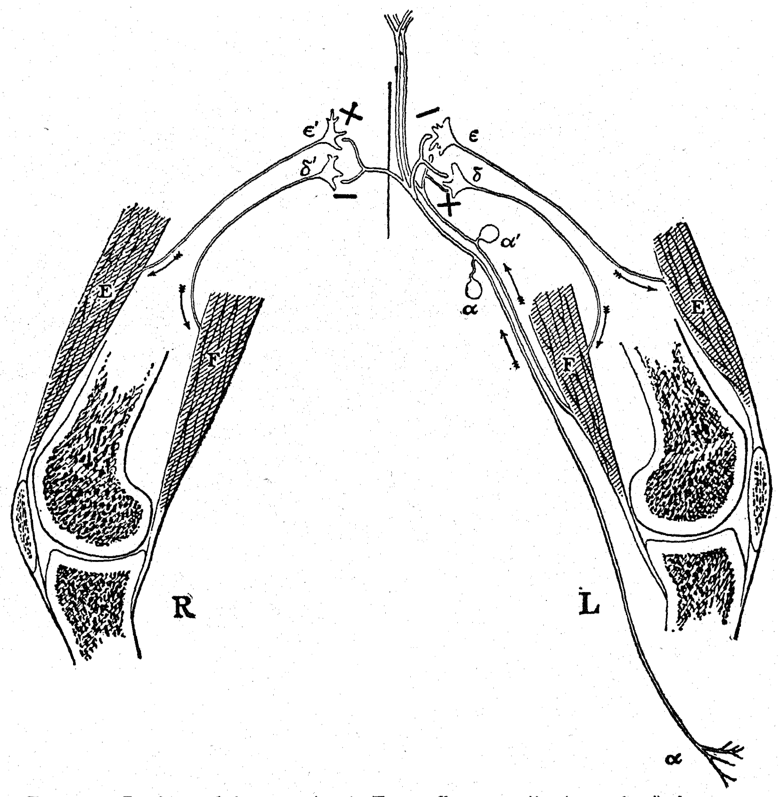

FIG. 12.—Reciprocal innervation. Two afferent cells (α and α') innervate the extensor and flexor muscles of the two knees. α afferent originating in the skin below the knee; α', an afferent fiber from the flexor muscles of the knee; ϵ and ϵ', efferent neurons to the extensor muscles of the knee, left and right; δ and δ' efferent neurons to the flexor muscles; E and E', extensor muscles; F and F', flexor muscles. The sign + indicates that, at the synapse so marked, the afferent fiber α (and α') excites the motor neuron to discharging activity, whereas the sign − indicates that, at the synapse so marked, the afferent fiber α (and α') inhibits the discharging activity of the motor neurons. The diagram is to be understood as a representation of functional relationships, which can be observed, rather than as an indication of fixed anatomical connections (see text for discussion of shifting relationships.) (*From C. S. Sherrington. Integrative action of the nervous system, p.* 108. *New Haven: Yale Univ. Press,* 1906. *By permission of the publishers.*)

HIGHER AND LOWER LEVELS OF CONNECTION

The Main Masses of Tissue and Their Interconnections.—Figure 13 shows the main masses of nervous tissue. The reflex actions

which we have been considering, thus far, have involved a limited segment of the spinal cord, together with afferent and efferent con-

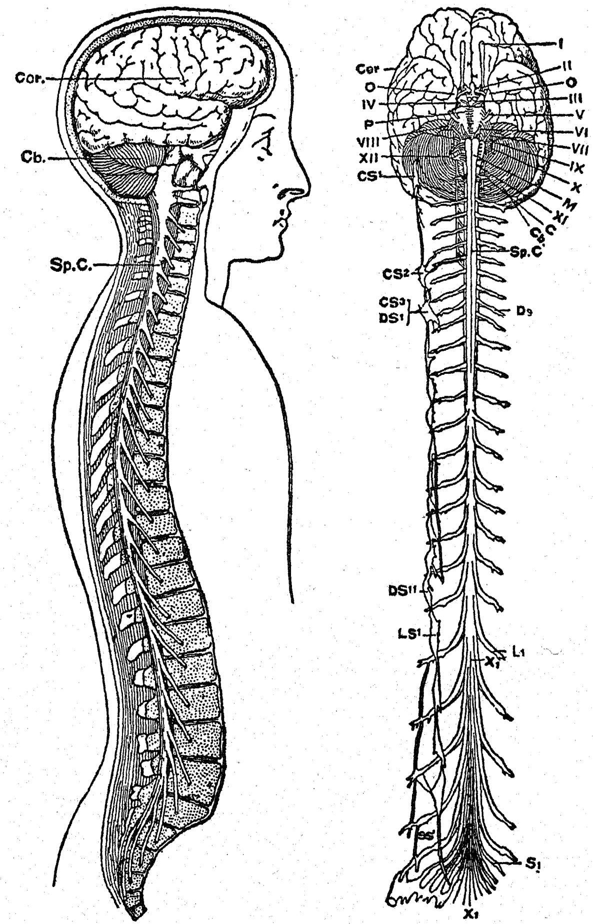

FIG. 13.—Nervous system as a whole. The figure on the right gives the appearance of the nervous system when seen from the front, with the cerebrum tilted upward exposing the underlying structures. *Cer.*, the cerebrum; *Cb.*, the cerebellum; *Sp. C.*, the spinal cord; *P*, the pons; *M*, the medulla. The other letters in the right-hand figure indicate nerve trunks going to the autonomic nervous system and the body as a whole. (*From J. R. Angell. Psychology, p.* 30. *New York: Holt,* 1909. *By permission of the publishers.*)

nections. Such isolated activity is not typical in the behavior of the intact animal. The afferent paths which enter the cord may rise

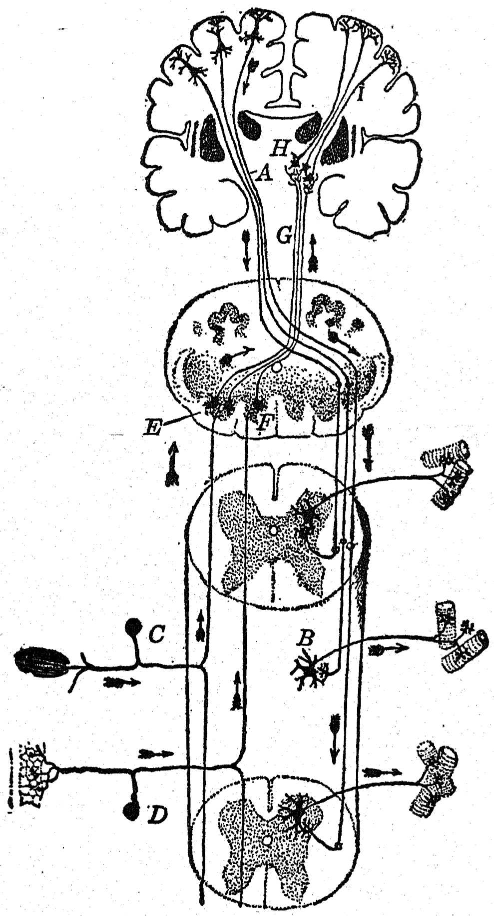

FIG. 14.—Schematic diagram showing ascending and descending tracts between the cord and cortex. *A*, pyramidal tracts carrying descending impulses down to motor neuron in the ventral gray of the cord, whence the impulses are relayed out to striped muscles; *B*, cell of motor nerve; *C*, *D*, sensory cells whose axons ascend the cord to terminate about nuclei in the medulla, *E*, *F*; from here the impulses are relayed by a second set of cells to the thalamus, *H*, where a third set of cells completes the path to the cortex. Note that both ascending and descending tracts cross to the opposite sides. (*From W. B. Pillsbury. Fundamentals of Psychology, p.* 35. *New York: Macmillan,* 1934. *By permission of the publishers.*)

directly to the level of the medulla (Fig. 14),[1] where they terminate near a group of relaying cells located in the central gray matter.

[1] Impulses from each type of receptor are gathered together in rather well-defined groups, or "bundles," each tract occupying a definite position in the

The latter continue to the thalamus (*H*) and join a third group of cells which extend to the surface of the cerebral cortex. (Cerebrum, thalamus, and medulla are also shown in Fig. 15.) Descending paths, originating in large pyramid-shaped cells located in front of the central fissure of the cerebral cortex, descend to terminate around

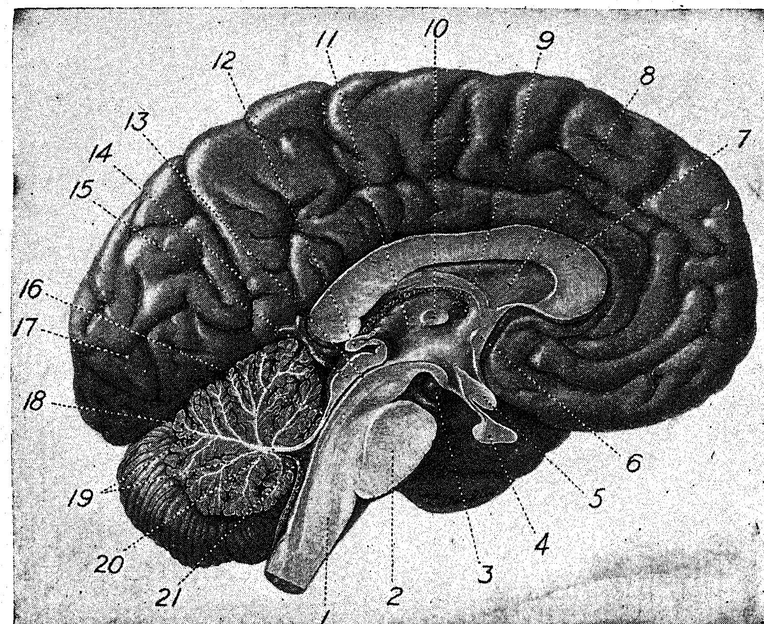

FIG. 15.—Vertical median section of the brain, showing the left half. The upper mass (above the arched *corpus callosum*) is the cerebrum upon whose high degree of development so many human capacities depend. (*After Watson. From J. F. Dashiell. General Psychology, p.* 280. *Boston: Houghton Mifflin,* 1937. *By permission of the publishers.*)

the motor cells at various levels of the cord. It will be noted that both ascending and descending paths cross to the opposite sides of the body. Some of the consequences of this fact will appear later in the discussion of the effects of cortical lesions.

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cord. Such ascending bundles (in the white matter of the cord) are sometimes interrupted by accidental injury, tumor, or disease of the nerve tissues, and as a result sensibility below the lesion is lost. If the lesion is sharply localized, this loss may be confined to one sense field, *e.g.*, pressure. Temperature and pain impulses, traveling in adjacent tracts may drop out together.

Such diagrammatic simplifications do not, of course, more than hint at the manner in which these neural masses are bound together. Long and short paths bind together the various levels of cord and brain stem, every group of cells on the right has connections with corresponding units on the left. Interruptions in descending paths at various levels, in which axon end brushes, or collaterals, enter the gray of the cord, permit integrations of every complexity. Conversely, if we consider the single motor neuron (see Fig. 16) we see that parallel descending paths from cortex, thalamus, cerebellum, midbrain, medulla, and from the near-by cells at the same level of

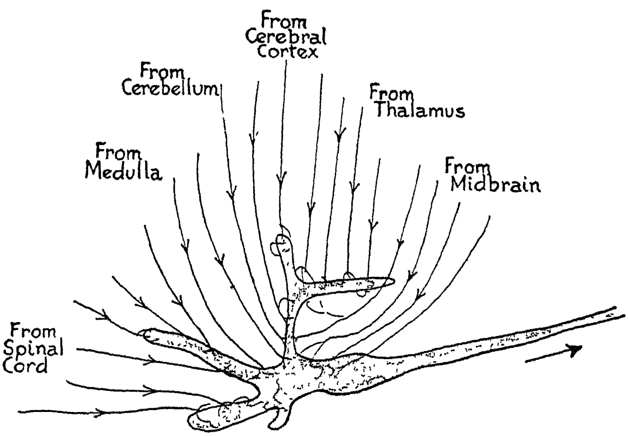


FIG. 16.—Diagram of a motoneuron and its connections. (*From G. L. Freeman. Introduction to physiological psychology, p. 170. New York: Ronald, 1934. By permission of the publishers.*)

the cord, all converge upon this single "final common path." The action of a local segment is thus brought under the influence of the widest range of stimulation; and a corresponding diagram of the afferent system would show that the entering stimulus is carried over paths which give it the widest possible distribution.

Some neurologists have compared this conduction system to a "loop-line" arrangement. An entering impulse may thus be conceived as crossing the cord directly, making an immediate connection with the motor neuron at the same level, or as rising through a loop-line detour, *e.g.*, connecting with an efferent path at, say, the medulla (*cf.* Fig. 17). As a matter of fact, the entering impulse will take both paths, and since the possibilities of connection at any and all levels are so numerous, we may picture an enormous number

of such loop lines normally at work. To this must be added the reminder that not one but literally millions of afferent cells are constantly carrying waves of sensory excitation into every level of this loop-line system. The fact that such an influx of excitation produces orderly and patterned response is indeed a cause for wonder. We have seen, however, in the spinal reflex, how antagonistic muscle groups "clear" for one another (chronaxie tuning, reciprocal innervation, etc.). It remains for us to seek some evidence of similar arrangements in the system as a whole.

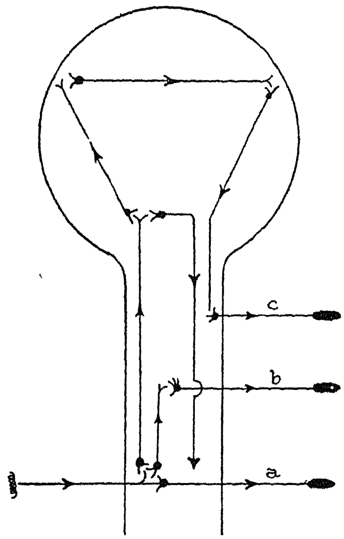


FIG. 17.—Loop-line plan of nervous conduction. The entering impulse may arouse an effector at the same level (as in *a*) or may be carried to other levels of the cord (as in *b*). Loop-line connections with *a* are shown at the level of thalamus and brain stem and also at the highest cortical level. Since these higher loop-lines are accessible to other afferent lines, the responses mediated by these higher circuits will show a "situational" rather than a local type of control. (*From G. L. Freeman, op. cit., p.* 150. *By permission of the publishers.*)

A Hierarchy of Levels.—Our description of reflex action has centered attention upon a limited segment, or fragment, of the organism. In the intact organism impulses are not simply routed through the spinal cord at their level of entry, nor is the behavior of the organism simply the sum of such segmental responses. There exists, rather, a hierarchy of "centers" as we pass up the cord and brain stem. When, as in the "thalamic" animal, all the structures below the cerebrum are present, we observe an animal that is capable of reflex standing (and even running). There is thus a total postural integration in which the trunk and four extremities cooperate.

It seems proper to speak of a hierarchy since the higher levels of the nervous system provide the paths through which the separate lower segments are brought together, and in this sense these higher structures may be said to control the lower ones. There is some danger that we shall drift back into the animistic way of thinking, in employing such a word as "control"; but a concrete analysis will do much to reduce the animistic factor. In truth, it is not a group of cells in the center to which we delegate

the task of integrating and coordinating the elements in a plan of action. These cells but provide a protoplasmic conduction system through which the outlying peripheral structures may mutually influence one another, and all be brought under the sway of ever-widening environmental matrices.

For one thing, as we pass up the cord and brain stem we discover not merely larger patterns of integration (tying together remote bodily segments), but a more labile and variable set of coordinations. The activity in each part now reflects all the stresses operative in the remote segments. The controlling[1] function of the higher centers is also shown by the release phenomena which follow the cutting of the cord or brain stem. In general, the reflexes below the cut are exaggerated, as though freed from the regulatory inhibition of the higher centers. In analogous fashion, conditions which depress the functioning of the highest centers of the cerebral cortex are accompanied by loss of control (*i.e.*, by excitement, by exaggerated movements, and by exhilaration, or violent weeping, etc.). One thinks at once of the behavior of the intoxicated person, or of the person just emerging from an anesthetic. His brutal frankness, his risqué witticisms, his exaggerated speech and movements of the extremities, all show that his reflexes are no longer subordinate to the same inhibiting and controlling influence that a normally responding set of higher structures supplies. The staggering gait of the intoxicated person shows that special muscle groups are enjoying an unwonted "independence." Head, eyes, trunk, and limbs pursue their several courses: the regulatory, integrating centers are depressed.

But if we are to avoid the animism which continually haunts psychological reasoning (and the physiologists who write about the functioning of the cortex are not above reproach) we must not think of these higher cells as originating commands, or countermanding orders from the periphery, in an altogether autonomous fashion. From what we know of nerve action any cell has but one task, namely, to relay the impulses which are brought to it. The cells of the higher structures can relay only the "commands" which reach them via the afferent paths which originate at the periphery. In this sense the sense organs issue commands, and the muscles issue

[1] The student is warned against giving this term an animistic significance. These highest cell groups, like other nerve cells, relay impulses which originate at the periphery. It may help to remember that the subscribers who put in calls also control the central switchboard in an automatic telephone exchange.

commands, and each cell on a connecting chain commands its neighbors. If there is any special sense in which the higher centers are "in command," then it lies in the fact that (1) they are the points through which the over-all activities regulate themselves (*i.e.*, they are the convergence points for the widest afferent streams), and (2) they are the "ports of entry" for special groups of impulses important for posture, and (3) they are immediately associated with the distance-receptor paths.

Postural Reflexes Involving Different Levels.—We have already noted a simple case of postural coordination at the spinal level. In the reflex withdrawal of the hind foot of the spinal dog the animal's weight is shifted to the opposite leg (*i.e.*, flexion on one side is accompanied by an increase in extensor contraction of the opposite side). Similar coordinations between head and trunk, between forelimbs and the lower extremities, resulting in characteristic over-all attitudes, or postures, appear when the thalamic and brain-stem structures are preserved. Changing the position of the head of the decerebrate animal initiates a total pattern; limbs and trunk assume characteristic alignments.

We might illustrate these relationships in the case of a cat attentively following the movements of a mouse. The movements of the mouse "catch the eye" of the cat, and as the mouse moves to the right, the eyes and head of the cat follow. The head movement shifts the weight on the forelegs, stretches the muscles of one side of the neck, and stimulates the vestibular apparatus. If the movement of pursuit is toward the right, the right foot will be extended, supporting the weight of the forequarters and head; the left foot, released, is lifted and the trunk curves and adjusts to the new head-foreleg posture.

Chief, perhaps, among the "regulators" in such postural adjustment will be the vestibular apparatus. To show its action, Magnus[1] removed the effects of all neck receptors (either by bandaging head, neck, and trunk, so as to eliminate all movements and torsion, or by severing sensory roots supplying the skin and muscles of the neck). He found that for each head position there is a characteristic pattern of tonus in all the antigravity muscles, and that the postures lasted for long periods, being practically indefatigable. With unilateral labyrinthine extirpation the animal (decorticate rabbit) turns the

[1] Magnus, R. Animal posture (Croonian Lecture). *Proc. roy. Soc.*, 1925, B98, 339–353.

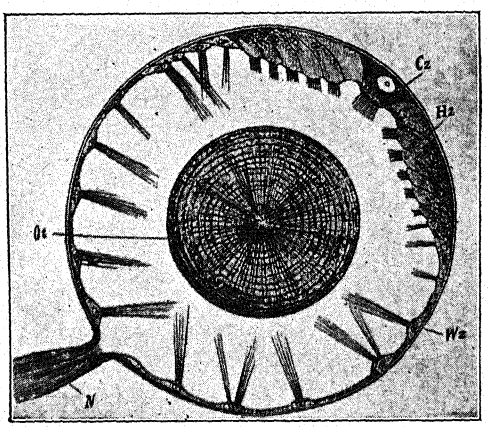
head to one side, extends one foreleg, flexes the other—as long as the animal lives.[1]

The Vestibular Apparatus.—Most of the freely moving multicellular animals possess saclike organs (otocysts) which function in maintaining their equilibrium. Lying near the surface, and indeed sometimes open to it, the sac is richly supplied with nerves which commonly terminate in hair cells (see Fig. 18). Within the sac is found an otolith, usually of calcium carbonate. One can see at once that any change in the animal's position will result in a corresponding change in otolith pressure upon the hair cells. That such pressure is closely connected with the equilibrating reactions was shown by Kreidl (1893) who demonstrated the function of these structures in the crayfish. When these creatures shed their chitinous covering (as they outgrow it) they lose (in some species, at least) the inner lining of the cyst organs, together with the otoliths. Ordinarily the latter will be replaced by granules of sand. By so placing the animals that they were forced to take in iron filings, and then placing a magnet above the animal, Kreidl was able to produce a variety of modifications of posture. The filings, drawn to the top of the otocyst, induced "righting" reactions of such a nature that the animal progressed on its back.

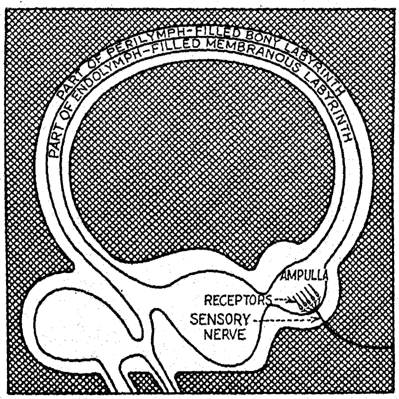
In man these structures develop as an adjunct to the inner ear. They may be seen in Fig. 19 and as *S* and *U* in Fig. 20. The sacculus and utriculus are the structures containing the hair cells and otoliths (comparable to the crayfish structures). In addition, the utriculus may be seen to possess three semicircular appendages, each appendage, or canal, lying in a plane perpendicular to that of the other two. These canals are so arranged that any movement of the head will cause a stimulation of the hair cells contained in the epithelium which lines the ampulla (the swelling to be noted at one end of each canal near the utriculus). It is generally believed that the rapid movement of the head, carrying as it does the hair cells with it, causes them to be stimulated as they move through the more or less inert liquid. Both the ampullae and the hair cells of the sacculus and utriculus are supplied by the vestibular nerve, whose fibers carry the impulses to the near-by brain stem, from whence they are relayed to the cerebellum.

[1] Dusser de Barenne, J. G. The labyrinthine and postural mechanisms, *Handbook of experimental psychology*, p. 204. Ed. by C. Murchison. Worcester: Clark Univ. Press, 1934.

Experiments have shown that extirpation or stoppage of the semicircular canals results in marked disturbances of equilibrium.



A



B

FIG. 18.—*A*. Statocyst of pterotrachea (a free-swimming mollusc). *N*, nerve; *Ot*, otolith in the interior of the sac, which is filled with liquid; *Wz*, hair cells on the inner surface of the wall; *Hz*, *Cz*, cells with short bristles, supposed to be the sensitive cells. (*From Claus. Elementary textbook of zoology, p.* 86. *London: Swann Sonnenschein,* 1884. *By permission of The Macmillan Company, publishers.*
B. Semicircular canal in man. Pressure of the moving liquid upon the hair-cell receptors arouses the impulses which lead to compensatory postural adjustment. (*From H. C. Warren and L. Carmichael. Elements of human psychology, p.* 138. *Boston: Houghton Mifflin,* 1930. *By permission of the publishers.*)

Pigeons so treated are unable to fly; indeed, even standing or maintaining a fixed posture seems impossible. The effect, however, seems to decrease in time, though it never disappears entirely, and

it is probable that other sources of stimulation come to substitute for the vestibular apparatus. Just as the patient with *tabes dorsalis* may learn to substitute a visual control for the kinesthetic, which is here destroyed by the spinal cord lesions, these operated pigeons may learn to get about on the basis of substitute cues. It is interesting to note that extirpation of the cerebral hemispheres will bring

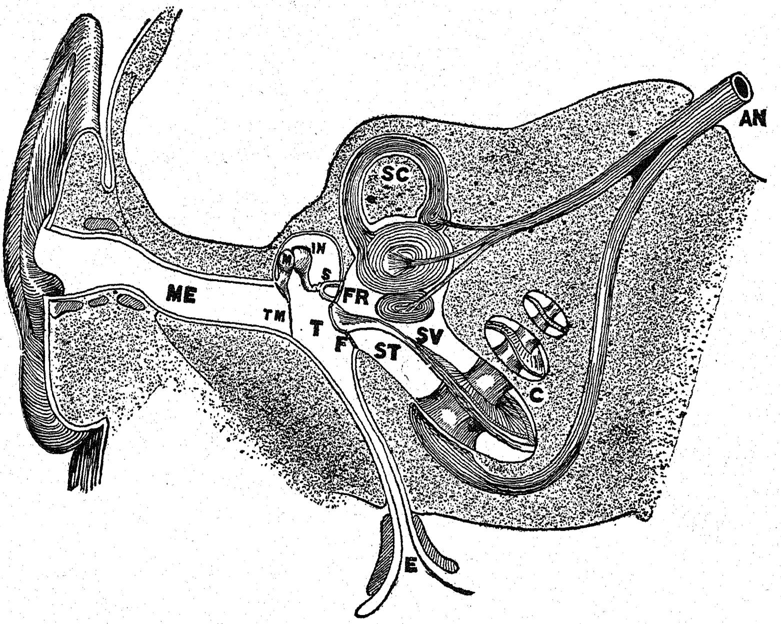


FIG. 19.—Diagrammatic section through a portion of the human cranium to show the parts of the ear.

ME, external meatus; *TM*, tympanic membrane; *M*, malleus; *IN*, incus; *S*, stapes; *SC*, semicircular canals; *T*, tympanum or ear drum; *FR*, *fenestra ovalis; F*, *fenestra rotunda; ST*, scala tympani; *SV*, scala vestibuli; *C*, cochlea; *E*, Eustachian tube; *AN*, auditory nerve. (*After Czermak. From P. N. Mitchell. General physiology.*

back all the symptoms. The significance of this fact will be appreciated when it is known that in birds with vestibular apparatus intact such cerebral destruction produces no postural disturbances.[1]

Two observations from everyday experience will serve to point out the wide range of effectors aroused by vestibular stimulation. The

[1] Starling, *op. cit.*, 4th ed., p. 317. Starling notes, too, that bandaging the eyes of the pigeon which has developed substitute methods of postural control brings back all the symptoms in their full severity.

nausea and stomach contraction of seasickness and the rapid, jerky eye movements of the person who is dizzy from rotation both spring from vestibular stimulation. The sweep of vision, which is neatly integrated with the movements of head and body, depends in large degree upon the integration of the vestibular and the oculomotor apparatus.

The reflex responses to rapid shifts in posture, while more dramatic, should not be allowed to obscure the important function of the vestibular apparatus in regulating and maintaining posture. Animals whose vestibular apparatus is destroyed show a general weakness, particularly of the neck and trunk muscles; if the extirpation involves but one side, this loss of tone appears chiefly in the musculature of the opposite side of the body. If a dog, both of whose labyrinths have been removed, is induced to jump from a table to the floor, his foreleg and neck muscles do not seem to be able to take up the shock of the jump, and head and trunk collapse against the floor.[1] The abnormal postures of the operated animals, and the localized loss of tone when one side is destroyed, clearly indicate the importance of the vestibular stream in maintaining normal muscular tone. Since with each change in head posture there will be characteristic patterns of vestibular stimulation, there should also be characteristic patterns of muscular contraction, providing either compensatory movements or the implicit contractions which we refer to as *tone*—and this is precisely what the experiments of Magnus so clearly demonstrate. Since the head also contains the distance receptors, the eye and the ear, the head reflexes initiated when the latter are stimulated by the wider outer environment will produce through the associated vestibular-cerebellar reflexes an automatic alignment of the entire posture.

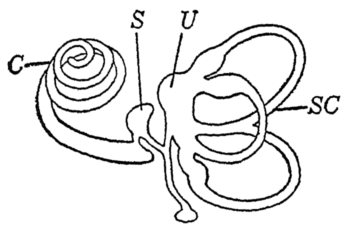


FIG. 20.—Model of labyrinth of the human ear. The semicircular canals (*SC*) and the attached saccule (*S*) and utricle (*U*) are the organs of equilibrium. The coiled spiral (*C*) is the cochlea within which are the auditory receptors. (*From C. E. Seashore. Introduction to psychology, p. 412. New York: Macmillan, 1924. By permission of The Macmillan Company, publishers.*)

The Cerebellum.—In all this discussion there has been no mention of the cerebellum, lying back of the brain stem immediately

[1] *Ibid.*, 3d ed., p. 655. Philadelphia: Lea, 1920.

beneath the cerebrum. It is commonly designated as the "head ganglion of the proprioceptive system," and it is richly supplied with afferent paths from the muscles and tendons, as well as from the vestibular apparatus. Human subjects with cerebellar lesions commonly show a loss of muscular tone, excessively abrupt and unsteady movements, faulty combinations of contraction. The fact that some of the symptoms of cerebellar lesion resemble those found in lesions of the spinocerebellar tracts (which carry proprioceptive impulses from the cord centralward) strongly suggests that the cerebellar control of posture is basically proprioceptive control. The voluntary movements of the organism as a whole undergo changes (in cerebellar injury) comparable to those in the reflex preparation that is de-afferented. It should be pointed out, however, that removal of the cerebellum does not cause any loss of sensation.

Neurologists list the following characteristics as commonly associated with cerebellar injury:[1]

1. A marked tremor in voluntary movements ("intention tremor").
2. Ataxia. The antagonistic muscles do not show the proper timing and the synergists do not provide a proper support for the movements. (Movements are "flung," in normal subjects, from rigid supporting muscle groups. If these fail in either strength or timing, awkwardness, inaccuracy, and "wobbly" postures result.)
3. Evidence of the general ataxia is shown by the following: *adiodokokinesis* (the inability to execute rapidly alternating movements, *e.g.*, pronating and supinating the arms), *dysmetria* (faulty adjustment of the contractions to distance), slurring speech, illegible handwriting.
4. Catalepsy. There is a tendency for postures to persist, even when they are clearly uncomfortable for the subject.
5. Hypotonia. The limbs, when moved passively, appear "floppy," loose. The patient is easily fatigued. Lesions of the vermis (mid-portion next to the brain stem) affect the trunk movements, gross posture. The individual sways as he walks, spreading his legs to provide a broad base for his movements. Lesions to the hemispheres disturb finer movements, particularly of the upper extremities. Movements undergo decomposition, and at the same time added "flings" appear.

Just as the spinal center correlates the action of two limbs in the spinal animal, the higher levels of the brain stem and cerebellum

[1] See Fulton, J. F. *Muscular contraction and the reflex control of movement.* Baltimore: Williams & Wilkins, 1926. Grinker, R. R. *Neurology*, 2d ed. New York: Thomas, 1937. Starling, E. H. *Human Physiology*, 5th ed., p. 334. Ed. and rev. by C. Lovatt Evans. Philadelphia: Lea, 1930.

provide the tracts through which a total posture is integrated. A most complex reflex adjustment keeps the organism balanced and the parts appropriately adjusted. Eyes, neck, trunk, limbs are bound into a reacting unit. Since a stimulus is always impressed upon a dynamic unity variable effects are inevitable. The pattern of peripheral contractions and the attendant state of affairs at the centers (excitatory or inhibitory states, chronaxies of subordination) provide a "resident," or organic, control equally important in determining the ensuing pattern of contractions. Shifts in the position of head and eyes apparently alter the pattern of tonus in the rest of the musculature. Postural changes alter the "sign" of the reflex which an external stimulus will release.

Our hierarchy of centers might be compared with the relations within an army. The midbrain centers are like the regimental or divisional headquarters, in contact with the "front," on the one hand, and with the general staff (cortex), on the other. The order from headquarters (based upon the widest possible information from all parts of the sector) leaves many details to the regimental commander. The efficient regimental commander, on his part, keeps his unit "integrated" (in trim fighting order) and ready for the most diverse commands. A certain amount of autonomy is left to the smallest unit (spinal reflex) on the line. There may be, for example, a "reflex" exchange of shots, an immediate answer to an attack; but for the most part local actions will be subordinate to the progress of affairs on the sector. The decisions at headquarters, on the other hand, require a constant stream of reports from each sector of the front (ascending afferent bundles).

In this hierarchy of reflexes, however, there is the most democratic arrangement conceivable. The decisions of the high command represent the communal voice of the private soldiers of the line (muscles and receptors at the periphery). If the position of the head and eyes can impress a postural pattern upon the rest of the effectors, so a local peripheral disturbance (*e.g.*, painful stimulus to the hand) can mobilize the head and eyes. From center to periphery, and from periphery to center, there is a constant interchange and interpenetration of commands.

In at least one respect the analogy breaks down. The work of these brain-stem and cerebellar centers is automatic. The individuals who carry on the transmission of messages are automata, and the "decisions" are like those which an automatic telephone exchange

makes. There is no "awareness," no "judgment," no "planning," as we ordinarily understand these terms.

The Autonomic Reflexes

The So-called "Involuntary" Responses.—The effectors which we have been considering up to the present time have all been striped muscles, attached to the bony framework of the body. These are the muscles which move us through space, and when they are coordinated into nicely timed temporal patterns they constitute our skills. We commonly describe them as "voluntary" muscles, since they come to obey our "commands," and are subservient to our "will." Connected directly with the spinal cord, and indirectly—through relaying neurons—with the brain, physiologists frequently describe them as under "cortical" control, although we have seen that they contribute as much to the "center" as they receive.

There is a second group of effectors which must be considered—the involuntary muscles and glands. These involuntary, or smooth, muscles are for the most part arranged in sheets and form the tubes and pouches of the alimentary canal, the circulatory system, etc. We are not able to control these effectors with the same degree of efficiency; and instead of being progressively integrated (and individuated) into varied patterns subject to the "will," they tend to remain on the reflex level, responding en masse. Thus, startled by the sudden sound of a pistol shot, our hearts pound, digestive contractions stop, our face blanches and breaks out in perspiration, and our breathing is disturbed. In contrast to the power of the sudden stimulus to invoke and mobilize such widespread effects, our voluntary attempts to regulate the heart rate or the action of the sweat glands are quite ineffectual. Smooth muscles and glands operate with such a degree of independence that we refer to them—along with their neural connections—as the autonomic system. Our body's temperature is thus maintained automatically at 98.6°, our food is automatically digested by stomach and intestines, our respiration adjusts itself to the oxygen needs of the tissues; and all this takes place without our giving such matters the slightest thought.

The Autonomic Pathways.—The neural architecture for such reflexes is in some respects different from that which regulates the skeletal musculature. For one thing, the efferent fibers which reach these effectors lie entirely outside of the central nervous system, their cell bodies joined in clusters, or ganglia, outside of the spinal

cord. The ganglia lie, for the most part, in two rows, in front of and slightly to the side of the spinal cord. In some cases they are embedded in the tissues of the organs which they supply. These efferent cells are not, however, entirely dissociated from the spinal cord and brain stem. They are supplied with fibers—called preganglionic fibers—whose cell bodies lie within the central nervous system. Figure 21 shows such cells lying within the gray matter of the spinal cord with extension lines relaying impulses from the cord to

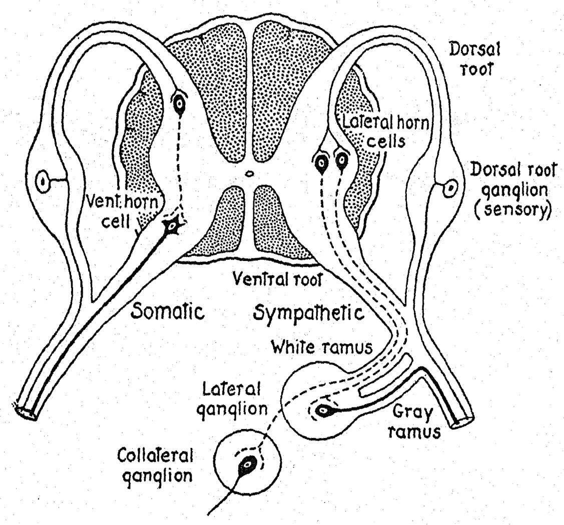


FIG. 21.—Diagram illustrating the different arrangements of neurons in somatic and autonomic nervous systems. The autonomic reflex path shown on the right contains a preganglionic fiber (shown in broken lines) and a postganglionic fiber (solid lines). (*From J. J. R. McLeod. Physiology and biochemistry in modern medicine, p. 990. St. Louis: Mosby, 1935. By permission of the publishers.*)

the smooth musculature. All the efferent paths to smooth muscles and glands are thus broken (with the exception of the path to the adrenal glands, which are directly penetrated by preganglionic fibers).[1] In the diagram for the autonomic reflex, therefore, the chief difference which we note is the interposition of the relay cells. It will be noted that the afferent portion of the autonomic circuit, shown in Fig. 21, follows the usual route for afferent impulses, entering the cord at the rear, via the usual T-shaped cell. There are no

[1] In this latter case there are morphological and embryological considerations which help to account for the exception. The secreting cells of the medulla arise from the morphological equivalent of postganglionic neurons.

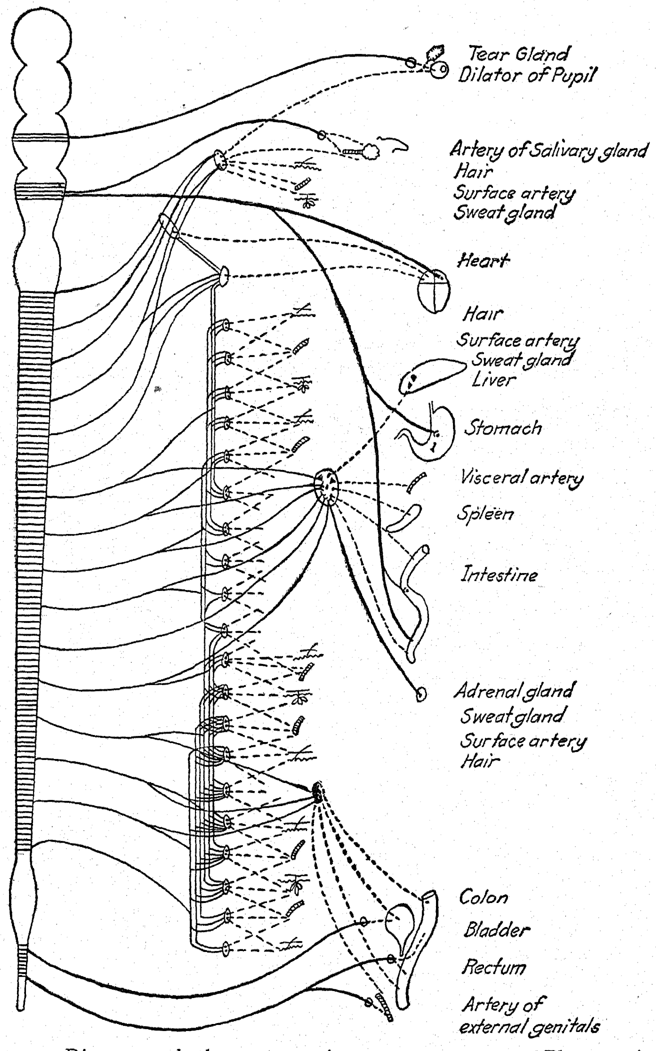


FIG. 22.—Diagram of the autonomic nervous system. The craniosacral division (upper and lower sections) is indicated by solid black lines; the sympathetic division (middle section) is indicated by dash and dot lines. (*From G. L. Freeman. Introduction to physiological psychology, p.* 176. *New York: Ronald,* 1934. *Modified from Meyer and Gottlieb, Experimental Pharmacology, Chicago: Lippincott. By permission of the publishers.*)

outlying junctions, joining the afferent nerves arising in the smooth musculature with the postganglionic efferents. In an autonomic reflex circuit the spinal cord is involved in much the same manner as in the skeletal muscle circuit. The mere interposition of a relay certainly fails to account for all the difference between the voluntary and involuntary systems.[1]

Divisions of the Autonomic System.—The autonomic system is divided, both architecturally and functionally, into three divisions: cranial, sympathetic, and sacral. Where the spinal nerves supplying the arms and legs leave the spinal cord there are no preganglionic fibers, or ganglia, and these breaks in the preganglionic system serve as boundaries for the sympathetic division. Emerging with the motor nerves from the cord, the preganglionic fibers part company with those bound for the skeletal muscles, and enter the ganglia. In the sympathetic division these ganglia are distributed chain-wise in front of the cord, as shown in Fig. 22. Each spinal root reaches several ganglia and within the ganglion a single preganglionic fiber will innervate several ganglion cells, so that the sympathetic network provides a rather closely knit diffusion system. At the upper end of the chain several ganglia are joined, forming the larger stellate and cervical ganglia; and other outlying ganglia (or plexuses), either embedded within or lying near the tissues which they innervate, supply the circulatory, pulmonary, and alimentary organs. Widely distributed throughout the body, the fibers of the sympathetic division carry impulses which accelerate the heart, inhibit the smooth muscles of the alimentary tract, dilate the pupils, constrict the surface blood vessels, stimulate the adrenal, thyroid, and sweat glands, stimulate the liver to release sugar into the blood, dilate the bronchioles, contract smooth muscles attached to hairs, inhibit salivary secretion, contract smooth muscles of the internal genital organs, relax the bladder, contract the spleen.

In addition to the innervation which provides for diffuse response, the hormone secreted by the adrenal glands, entering the blood stream, has the power to duplicate most of the effects which sympathetic innervation accomplishes. Furthermore, Cannon's recent researches have shown that additional hormones (sympathin E and

[1] Cannon suggests that these relaying ganglion cells act as "transformers" stepping up the intensity of the impulses, and slowing down their rate for the more slowly responding tissues. Cannon, W. B. *Bodily changes in pain, hunger, fear and rage*, 2d ed., p. 21. New York: Appleton-Century, 1929.

sympathin I) are liberated when smooth muscles receive their sympathetic stimulation. It is possible, however, for fractions of the system to operate more or less independently. Thus the action of the sweat glands, tear ducts, hair muscles, pupils, may be carried on without a general disturbance over the whole sympathetic chain. Both fractional and diffuse actions are provided for.

The diffuse type of action seems characteristic of states of emergency, where efficient action calls for a release and mobilization of our reserves of energy. Thus asphyxia, prolonged exposure to cold, vigorous exercise, pain, rage, terror, typically involve a diffuse sympathetic action. Without the increased blood pressure, red corpuscles (from spleen), adrenalin, blood sugar, dilated bronchioles, etc., which constitute the general "state of alarm" evoked through the sympathetic mechanism, the organism would enter combat, struggle, flight, etc., with a severe handicap.

In contrast to this rather diffuse distribution system, the cranial and sacral divisions supply more sharply limited groups of tissue. Thus, in the cranial division, the third nerve supplies the tear glands and the dilators of the pupil, the vagus nerve has branches reaching the stomach, heart, and lungs, and in each of these cases the relaying ganglion lies either in or near the tissues themselves, and there are no interconnections or collaterals to provide for diffuse action. Again, in the sacral, the colon, bladder, external genitals are supplied from near-by ganglia. As Cannon observes:[1] "The sympathetic is like the soft and loud pedals, modulating all the notes together; the cranial and sacral autonomic are like the separate keys." This arrangement provides a double innervation for the various organs. Thus, the pupil is dilated by the sympathetic, constricted by the cranial; the heart is accelerated by the sympathetic, slowed by the vagus; digestive movements inhibited by the sympathetic, facilitated by the vagus; the blood vessels of the external genitalia are constricted by the sympathetic, dilated by the sacral division. (Exceptions to this rule are provided by a few structures which receive sympathetic fibers only: internal reproductive organs, sweat glands, blood vessels of the digestive tract.) In general, where the double and opposed innervations exist, the excitation of one division is accompanied by an inhibition of the opposed action, just as we observed in the case of opposed action in the skeletal reflexes. Thus,

[1] Cannon, *op. cit.*, p. 28.

while we observed the arrangements which made possible diffused action of the sympathetic, the inhibitory relationship existing between the craniosacral and the sympathetic branches, together with the more definite individuation of the craniosacral paths, provides for a great variety of patterns of action in the autonomic processes.

An additional observation may serve to characterize the functioning of the autonomic system. It will be noted that a division will sometimes operate as an excitor, and sometimes as an inhibitor. Thus, the cranial division slows the heart, excites salivation; and the sympathetic division dilates the pupil (constriction of radial muscles) and inhibits digestive contractions. We may see a certain unity in the action of the divisions, however, if we think of the cranial division as typically the "conserver of bodily resources."[1] The secretion of saliva and the gastric juice, churning contractions of the stomach and intestine, slowing heart rate, all characterize a relaxed, recuperative, energy-building phase. Coordinate with the cranial system, the sacral provides a set of emptying mechanisms,[2] removing waste from the bladder and colon. Opposed to these divisions, the sympathetic represents an emergency mobilization of resources, its emergency character being excellently portrayed in its ability to interrupt the more "placid" states. (In view of this it is often described as prepotent over the cranial and sacral divisions.) Such figurative descriptions should be used with caution, however, and any attempt to introduce a simple dichotomy in the autonomic functions must violate known physiological facts. The role of the sacral division in sexual excitement is a sufficient reminder that the cranial and sacral divisions have other than conserving or emptying functions.

The anatomical structures requisite for partial action exist, and clinical findings show them in operation. The reciprocal arrangements existing between sympathetic and craniosacral divisions, together with the more isolated ganglia of the craniosacral, apparently provide a mechanism sufficiently elaborate to yield an infinite variety of patterns of autonomic behavior. Whether or not human behavior yields, typically, certain massive and relatively invari-

[1] *Ibid.*, p. 29.

[2] The emptying of the seminal vesicles and the contractions which mark the sexual orgasm are mediated through the lumbar sympathetic. Cf. Kuntz, A. *Autonomic nervous system*, Chap. 13.

able groupings we shall have to examine later in our discussion of emotions.

It is probable that a hierarchy of "controls" exists within the spinal cord and brain stem (particularly the medulla and hypothalamus), so that something corresponding to the loop-line arrangement operating with the skeletal musculature will be found to obtain with the autonomic functions. Thus, both local and central control is provided for. But the conception of vegetative centers, each one of which is responsible for some vital function, is probably best described as a relic of that primitive animism with which most of our psychological and physiological thinking began. We need not look for a "circulation center" or a "respiratory center" any more than we should look for a "self-preservation" center. There are nerves running out to the respiratory muscles, to be sure, but the neural network which feeds those fibers has such wide ramifications that one may look upon respiration as under the influence of every stimulus which plays upon the organism. Similarly, the heartbeat will show the effect of lights, sounds, odors, etc.

The Cerebrum

Consciousness, the Cerebral Cortex, and the Organism.—We turn now to the group of cells which have been regarded as the home of the mind for generations. So far we have found no reason to consider such a factor as consciousness. Even the very complex postural responses of the "thalamic" animal are treated by the physiologist as automatic: no use is made of any explanatory principle other than those which suffice for the operation of the simpler spinal reflexes. True, the increasingly complex structures involved at the higher levels permit a remarkable degree of flexibility and cooperation between the parts; but the mechanisms have been able to run themselves. There has been no need to posit any quality of awareness, or "vigilance,"[1] which emerges as we ascend through the higher levels of the cord and brain stem.

[1] At least one physiologist, Henry Head, does make such a proposal. Since, however, it is never possible to give anything but a valuistic and qualitative description of such actions as are called "conscious" or "vigilant," the concept has not proved particularly useful to other physiologists. For a discussion of the concept see Head, Henry. Release of function in the nervous system. *Proc. roy. Soc.*, 1921, B92, 184–209.

The conception of mental and nervous energy (vigilance; a physiological state of the nervous system). *Brit. J. Psychol.*, 1923, 14, 126–147.

There is almost universal agreement, however, in associating those states which we call conscious, and in which we are most keenly aware of our surroundings, with some sort of *cortical*[1] activity. Our attending, perceiving, remembering, reasoning, willing, imagining are referred by neurologist and psychologist alike to activities in the cerebral cortex. Commonly a contrast is drawn between automatic and reflex activities of the cord and brain stem, and the purposive, intentional, conscious activities of the highest centers, with the clear implication that a new type of activity has emerged and that the principles which have sufficed for the lower levels will not apply to this highest level of action.

There is much to be said in support of this contrast. If the student of behavior were to confine himself to such activities as the maintenance of posture, reflex stepping and standing, the righting reflexes, the scratch reflex, the contrast between human and anthropoid behavior would practically disappear. There is scarcely an activity in the fields of posture and locomotion in which the higher apes cannot duplicate (and even surpass) man's performance. And even the animal lapses into a state of idiocy when the experimenting physiologist performs a cerebrectomy. How much greater the loss, therefore, when man is deprived of these structures! All that goes into the contrast between a "personality" and a "lump of flesh" hangs upon the possession of a little more than three pounds of neural tissue. However interesting the "thalamic" man might be to the physiologist and clinician, he would not be a pleasant member of one's household.

Without the cerebral structures man's educability, his capacity for social behavior, his speech, his thinking, and his reasoning powers would disappear. There is no question but what the emergence of specifically human action is associated with the evolution of the forebrain. Somehow these ten billion cells must be made to surrender their secret.

[1] The adjective "cortical" refers to the cortex (rind) of the cerebrum, composed of several layers of cell bodies (gray matter) and their connecting processes. The area of the cortex is much greater than the cerebral mass might at first suggest since it is arranged in numerous fissures and folds. Beneath this rind of gray matter a compact mass of connecting axons join part with part and (via the corpus callosum, shown in the medial section, Fig. 24(*B*)) unite the two lobes into one anatomical and functional whole. At the base of the cerebrum are other masses of cell bodies, divided into clusters of "nuclei" by bands of descending and ascending axons. These basal ganglia join with the thalamus in function.

To assert, however, that the cerebrum must be an integral element in all those activities which are distinctively human is not equivalent to a demonstration that man's consciousness resides within the skull box. From what we have learned of nerve impulses, and the general function of such tissue, it is natural to think that, like the peripheral nerves, the cells of the cortex are transmitters and integrators, unifying activity and connecting receptor and effector. Like the peripheral neuron, there is every reason to suspect that the cortical neuron obeys the all-or-none principle, that its business is to conduct, and that the terminus of the conduction path is a group of effectors. We shall find it hard to discover any reason why impulses should stop in any of these cells, or why electrochemical impulses should—at some one point on a neural path—suddenly "secrete" consciousness. Nor is there any reason to believe that cortical cells spring into action spontaneously, without the inciting stimulus so universally present at the periphery. There is every reason to believe that there are no special laws of neuron action which should govern these cortical cells. If these neurons mediate a new type of behavior, such new behavior must rest upon new structural arrangements, new modes of connecting receptor and effector—for, here as elsewhere, the business of the neuron is to carry a wave of electrochemical change.

May we not, therefore, accept reflex action as the prototype of all action, including that which is routed through the highest levels of the nervous system, and seek to describe the highest levels of human activity in precisely the same vocabulary we have used for the spinal reflexes?

If our analysis is correct, it will be better to think of the *whole man* as conscious, rather than a group of cells in the cranium. We shall think of sensing, perceiving, attending, desiring, thinking, as sensorimotor activities. While they involve the cortex, they also reach beyond it. The consciousness of the angry person dwells as much *in* the clenched fist and pounding heart (*pace* Hippocrates!) as *in* the cerebral cortex. Such a view will enable us to avoid the absurd position of those who seem to deny consciousness,[1] and at the

[1] Cf. Watson's dictum: "The behaviorist finds no evidence for 'mental processes' of any kind." Watson, J. B. *Psychology from the standpoint of a behaviorist*, p. 2. Philadelphia: Lippincott, 1924. This statement may be taken either (1) as a denial of the existence of conscious states or (2) a confession of the inadequacy of the behaviorist's methods. The first alternative denies the most

same time escape the logical problems of either granting an aspect of behavior causal power, or an independent existence.

To date, the solution of the problem of cerebral functioning, and of its relation to the totality of man's behavior (conscious and otherwise), has been seriously handicapped by the difficulties attendant upon direct observation of these brain events. To be sure, the introspectionist sometimes implies that he possesses a method of directly observing brain action; his reports, however, have shed little light upon the mechanisms at work. And while the introspectionist is reporting upon his conscious state, there is occurring such a welter of unanalyzed events (cortical, sensory, glandular, spinal, muscular) that mere subjective observation can neither locate the consciousness nor reveal the structure of the necessary physiological events.

We shall see later that there is excellent evidence for a synchrony between cortical and conscious events. It can be shown, too, that with the loss of cortical structures large fields of sensory and memorial material disappear. But such evidence merely tells us that *somehow* the cortex is involved in the conscious event. So, too, breaking a circuit may extinguish a glowing lamp bulb; but this by no means justifies a belief that the glow was "located" at the place where the circuit was broken. (Or that the glow activated and directed the flow of electrons.)

That some activities possess a unique quality for the one who experiences them we are certain. That these activities, which we call conscious, involve the cerebral cortex, we are also reasonably certain. Beyond this we cannot, for the moment, go. We may locate the damage which destroys these activities, but the quality itself (consciousness) eludes us. As we shall see later, there are cortically routed patterns of action which do not possess this quality; and there is evidence, on the other hand, that perhaps a duller and less discriminating consciousness may attach to some patterns at the thalamic level. It is not possible, however, in the present state of our knowledge, to state, finally, the crucial physiological differences between those actions which we call conscious and those which are unconscious. And the only possible way in which such a distinction can finally be clarified seems to be through an extension of those objective studies of these highest level activities. That is, by turn-

fundamental fact of experience, and makes unnecessary Watson's own chapter on thinking in the same volume.

ing away from the purely self-contemplative techniques of the traditional introspectionist we may discover something about the underlying structure of that which he professes to be interested in.

Methods of Studying Cerebral Functioning.—The objective evidence now on hand comes from many sources. All in all, its volume is so great that nothing but the sketchiest summary can be attempted here. Some of the evidence has been supplied by the study of diseases and injuries which result in the destruction of brain tissues, although all too often the indications have not been so clear as the demands of theory require. Further contributions have been made by the neuroanatomist, who has discovered methods of tracing the conduction paths, and from the comparative neurologist, who has followed the development of the more complex structures of the higher forms from their simpler beginnings in the lower animals. Embryology has contributed, too, in its account of the rise of the structures, and the histologist has described the cell types comprising the various cortical areas. Two additional methods come nearer to the direct experimental approach. In the method of extirpation, the physiologist removes small areas of brain tissue and observes the effect upon animal behavior. And finally, although the compact mass of cell bodies and their processes which compose the cerebrum does not present any easily isolated tracts across which the physiologist may lay his electrodes for recording and stimulating purposes, some direct observations of cortical activity have been made.

The Electrically Excitable Cortex.—The first case of direct observation was reported by Fritsch and Hitzig, in 1870, when they demonstrated that appropriate electrical stimulation of certain areas of the cortex would produce movement. Their experiment was suggested by a chance observation of Hitzig, who found that the eyes of a human subject responded when his cortex was stimulated. The investigators promptly turned to the dog, as a convenient experimental animal, and soon located five distinct areas from which they were able to elicit movements of the neck, foreleg, hind leg, and face. Rapidly a succession of investigations established the existence of a "motor" area, and within it independent areas supplying the main groups of muscles throughout the body (see Fig. 23). In the higher apes and man it was found that the electrically excitable cortex was rather sharply restricted to the area immediately in front of the central fissure and that, in general, an inverse relation between

position on the body and position on the brain surface held. Thus the cells exciting a flexion movement of the toes are located at the top, and those supplying the musculature of the face, jaws, throat, in the lower portion.

With sensory areas similar methods have been applied, though necessarily in limited fashion. Tampons soaked in weak solutions of chemical excitants were placed over limited areas of the cortex,

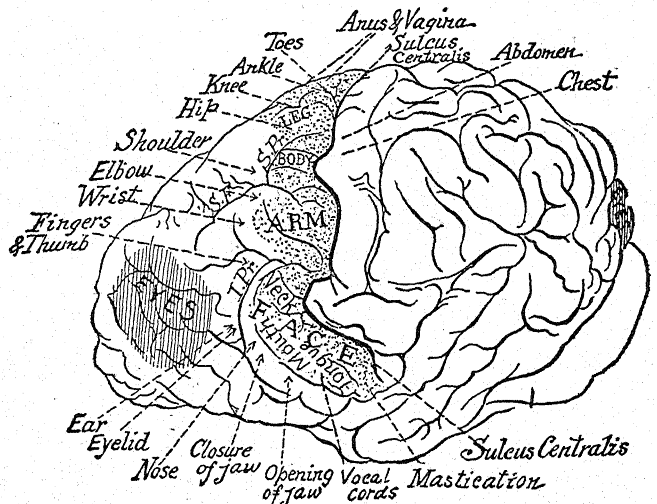


FIG. 23.—View of the left side of brain of chimpanzee with shaded areas indicating the electrically excitable portion. Note that portions of the occipital, as well as the frontal, area (see *EYES*) cause conjugate movements of the eyes when stimulated. The motor-projection area (stippled) is the point of origin of the descending motor fibers of the pyramidal tract, and body areas named indicate the parts which move when the cells of the projection area are stimulated. (*After Grünbaum and Sherrington. From C. J. Herrick. Introduction to neurology, p.* 315. *Philadelphia: Saunders,* 1918. *By permission of the publishers.*)

and the localizing gestures (licking and scratching) or the hypersensitivity of a specific sensory surface showed the functional connection between the stimulated brain area and the indicated surface. In other words, the irritation of the cortical cells set up reverberations similar to those which would be caused by persistent peripheral stimulation.

Stimulating the Cortex of a Waking Human Subject.—An instance reported by Dr. Harvey Cushing supplied introspective corroboration in the human subject. In the course of a brain operation, performed to relieve convulsions in a boy of fifteen, the patient was

brought out of the anesthesia and, with cortex exposed, electrodes were applied to both precentral and postcentral areas. In front of the central fissure movements were produced;[1] but in the post-Rolandic region the boy reported ill-defined sensations of warmth, of choking, and a complex group of sensations which were like those which had been preceding his convulsive attacks. In a second case, similarly observed, there was a rather precise localization of the "sensation," the subject localizing a "touching" or "stroking" on the fingers or upon the hand, the apparently touched points moving as the electrodes touched successive points of the cortex.

The Sensory Projection Areas.—This postcentral area (*C* in Fig. 24) is the "port of entry" for impulses involved in our appreciation of warm and cool objects, painful stimuli, pressures, changes in position of the body. In general, the order followed on the motor side of the fissure is repeated here. Dr. Cushing found, for example, that the point on the cortex producing sensations which appeared to originate in the index finger was located just opposite the motor point governing thumb flexion. The body is thus "projected" upon the brain surface in two areas, one of which supplies the musculature and one of which receives sensory impulses.

Immediately below this somesthetic area, extending into the cleft made by the fissure of Sylvius and out upon the temporal lobe for a short distance, is the auditory area. The destruction of this area on both sides of the brain results in complete deafness.[2] Reflexes to loud sounds may persist, but these will be felt as muscular and organic changes rather than as noise or tone.

On the undersurface of the cerebrum there is an area whose destruction is regularly accompanied by a loss of taste and smell (see *O* in Fig. 24).

The area mediating visual impulses has been most accurately mapped. It is located in the posterior portion of the brain, on the internal surfaces of the occipital lobes and including a small area at the tip. There is a point-for-point projection of the retinal surfaces upon these cortical areas. The sensory paths from the eye are divided on their way to the brain so that the right halves of the retinas supply the right occipital lobe area, and the left halves

[1] Cushing, Harvey. A Note upon the faradic stimulation of the postcentral gyrus in conscious patients. *Brain*, 1909, 32, 44–53.

[2] Whether or not there is the further punctiform localization within the area, comparable to that for vision, is still a disputed point.

supply the left occipital lobe. As a result, the destruction of the occipital area of one half of the cerebrum lessens the sensitivity of

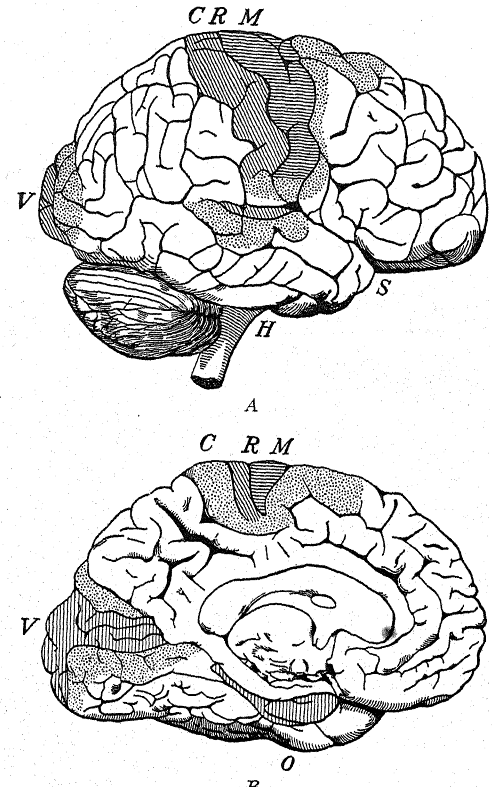


FIG. 24.—Diagrams showing the principal projection areas of the cortex. (*A*) The upper figure shows the outer surface of the right half of the brain. The fissure of Rolando (*R*) extending down and forward is bounded on the frontal side by the motor area (*M*). On the other side of the fissure is a cutaneous and kinesthetic sensory area (*C*), which extends downward along the fissure to the auditory area lying around a portion of the fissure of Sylvius (*S*). The *V* at the occipital pole (back of brain) indicates an area whose function is predominantly visual. The remaining areas (unshaded) are commonly referred to as the association areas, since their function seems to be an integrative one.

(*B*) The mesial surface of the left half of the brain showing the continuation of the motor, cutaneous-kinesthetic, and visual areas upon this inner surface. (*O*) is placed below the olfactory area (vertical lines in lower central portion of figure). (*After Campbell, Flechsig, Cushing. From W. B. Pillsbury. Essentials of psychology, pp.* 40–41. *New York: Macmillan,* 1930. *By permission of the publishers.*)

both eyes, cutting off one half of each field of vision. Sharply localized cortical injuries in this visual area produce permanent

blindness to objects within a limited section of the visual field. The victim of such localized blindness is only indirectly aware of his defect. He does not see any "hole" in the visual field. Instead, as in hemianopsia, his complaint is likely to be of his own awkwardness, and a tendency constantly to blunder into objects on one side. The discovery of the nature of his defect is as revealing to him as is the normal person's discovery of the retinal blind spot.[1]

The "Association" Areas.—Between the cortical areas which we have mapped lie what is known as the "association" areas. There is much disagreement as to the details of their functioning; but some justification for their name may be given in the fact that axons arising from these cells constitute a network of tracts joining each part of the cortex with every other part. But whereas all are agreed that a loss of cells within the visual area will induce partial or total blindness, a blindness that is specific for the lesion—and permanent, there are many conflicting accounts of what happens when these neighboring areas are destroyed. Does it cause a loss of intelligence, of capacity to learn? Or is it a loss of specific habits? Will it necessarily result in any noticeable defect?[2]

Mass Action vs. Localization.—Nearly all modern theories of brain action stress the unitary action of the cerebral hemispheres. Ascending impulses are not thought of as activating mere isolated patches of cortical tissues, nor is the incoming impulse shunted back to the musculature over a single insulated cable. Cerebral anatomy itself implies unified action. The seven or eight layers of cortical cells are enmeshed in interlacing fibrils, bundles of "association" fibers join the visual area with the other projection areas, the right half of the cerebrum with the left, etc. The mechanism

[1] Pieron, Henri. *Thought and the brain*, p. 120. New York: Harcourt, 1927.

[2] In the notorious case of Phineas Gage (1848), long quoted among the neurological marvels, a crowbar, driven by a charge of blasting powder from the hands of a quarryman, passed through the unfortunate victim's cheek and skull, pushing out a cylindrical mass of gray matter from the left hemisphere. It was reported that he did not even lose consciousness; he survived for twenty years, and showed no abnormalities beyond blindness of the left eye due to the severance of the optic nerve. Stiles, P. G., who quotes the example (*The nervous system and its conservation*, 3d ed., p. 178. Philadelphia: Saunders, 1924), adds the comment, however, that the catalogue of the museum in which Gage's skull is still preserved speaks of such symptoms as "irritability, profanity, irresolution, and, toward the end, epileptic seizures." Few cases wherein large masses of cerebral tissue have been destroyed with no adverse effects will bear rigorous examination.

for the diffusion of impulses is given with anatomical structure. But this is equally true of the spinal cord, and yet the entering impulse finds its appropriate motor neuron. And if we look upon the process of habit formation as one in which the receptor fields are somehow linked with effectors, will this linkage not necessitate the formation of specific interneuron "bonds"? May we not, in fact, frame the problem of learning in terms of the lowering of specific synaptic resistances, so that, for example, a specific visual pattern will come to incite a specific motor pattern by virtue of specific neuron-to-neuron bonds formed in the process of training? Then we may insist that although the impulse may, and usually does, spread throughout the hemispheres, it nevertheless spreads over definite prepared routes. Thus each mental event may be thought of as involving a characteristic cerebral route. Although we are unable to state the nature of the "trace" laid down by training (membrane changes, chronaxie "tuning," trophic and structural changes in dendrite and end brush), something of the sort has long been accepted as a necessary hypothesis.

As we shall see later, there are many clinical and experimental facts which raise difficulties for this view. As an example of the type of evidence let us consider the case of a human subject who learns in the course of a laboratory experiment to press a key when a certain pattern of lights is shown. If, during the training period, his right eye is bandaged, shall we expect him to fail in a test when the bandage is shifted to the other eye? Obviously not. Or if we change the size of the pattern, will the fact that it now falls on new retinal elements leave the subject without any knowledge of how to respond? The anatomical studies leave no question as to the direct connection between the retinal patch and the cortical patch. How, then, can the habit persist and function when the anatomical facts show that different routes through the brain are demanded? To this the "mass action" theory replies that the identity of the two situations is a dynamic and functional identity, and that the cortical reaction is more of the nature of a "field" than of a circuit limited to fixed conductors. Like the iron filings on a sheet of paper laid over a magnet, the neuron currents may be thought of as constituting a dynamic pattern. Such a dynamic pattern, involving the whole cortex, would be produced, even in the brain of the newborn child; but here, before experience has introduced its modifications, the pattern cannot initiate coordinated

movements of a very high level. The influence of training may be looked upon, then, as somehow linking the dynamic and formal character of this pattern with the muscular system. Just how this is achieved will be difficult to describe; but such instances as we have suggested above indicate that it may well be the "form" of a field of cortical excitation which is important, rather than the specific neurons involved. If this theory were pressed to its extreme it would imply that cortical tissue is *equipotential*, and that one path may function *vicariously* for another. As long as the stimulus has a "port of entry" into the cortical field, it matters little over what lines its pattern of excitation is transported. As long as an adequate connecting network is present, the habit may function.

In order to test these theories, we shall have to turn to the experimental and clinical facts. Unfortunately, for clarity's sake, these are not so unambiguous as they should be. That there is some localization, no one can deny. The electrically excitable areas, the ports of entry for auditory, visual, kinesthetic impulses, are all generally accepted. The dispute arises both with respect to the more complex functions and with respect to the problem of localization *within* a given sensory area. The "localizationist" may point to cases in which occipital lesions affect the patient's ability to see colors, without the loss of vision, and conclude that there are separate "chromatic neurons."[1] Similarly, when the capacity to read, or to perceive visual form, is disturbed without the destruction of vision, he is likely to conclude that in addition to a primary visual reception center (and probably adjacent to it) there is a "perceptual" area within which the incoming impulses are somehow integrated before distribution (again over specific trunk lines) to the rest of the cortex. Such losses, according to Pieron, may be highly specific, being limited, for example, "to printed signs . . . and even to certain of these signs, so that only numbers may be misunderstood, or, on the other hand, *only* numbers may be understood."[2] The loss of such specific habits with the retention of visual sensitivity suggests that the reverberation from the sensory ports of entry travels over specific connecting neurons. (We shall see later how the mass-action theory meets such facts.)

Even the extreme localizationist, however, does not attempt, in these days, to locate such faculties as attention, intelligence, memory,

[1] Pieron, *op. cit.*, p. 116.

[2] *Ibid.*, p. 123.

or perception. In either theory, complex mental activities involve the cooperation of remote cortical areas; even in the localizationist view, where specific memories are believed to occupy specific tracts, memory, as a general cortical capacity, is most diffuse. The one exception which still persists among reputable neurologists, and comes rather close to the ancient phrenological view, is the notion of a center for speech. We shall return to an examination of this notion as soon as we have made a brief survey of the recent experimental work upon animals.

Ablation Studies upon Animals.—The experimenter possesses so many advantages that his results may be regarded as basic in the interpretation of clinical findings. The clinician seldom has the opportunity to produce exactly the lesion he desires, and only occasionally does he have the brain of his patient for post-mortem study. The cortical lesions produced by tumors, blows, blood clots, are too often massive, affecting wide areas. Diffuse, poorly localized disturbances, accompanying the widest diversity of behavior disturbances, do not provide the correlations upon which advancing knowledge is built. One complete and well-controlled experimental study is worth hundreds of incomplete and indefinite clinical records.

Briefly, the technique of the experimenter is to establish a definite habit, to remove a portion of the animal's brain, to test the animal's performance after he has recovered, to kill the animal and determine with exactness the location and extent of the lesion. Or, if he finds that the lesion has destroyed the habit, he may attempt retraining; and if this is successful, he may then test the effect of further lesions. It is not possible to review, within limited space, the dozens of investigations which have pursued this technique with minor variations; but we may sketch the main outlines of their results.[1]

Simple Motor Skills.—When the animal (*e.g.*, rat) is taught a comparatively simple skill, such as depressing a platform or pushing a lever as a means of getting to food, it is found that the removal of the frontal lobes will destroy the habit. Partial destruction of the area will interfere with it, and the amount of interference seems to be roughly proportional to the size of the lesion within this

[1] More complete summaries may be found in Lashley, K. S., *Brain mechanisms and intelligence*, or in his chapter (Nervous Mechanisms in Learning, pp. 456–496) in the *Handbook of experimental psychology*. Ed. by C Murchison. Worcester: Clark Univ. Press, 1934. See also Mettler, F. A. Cerebral function and cortical localization. *J. gen. Psychol.*, 1935, 13, 367–401.

area. Small lesions may produce no measurable effect. Within the area there do not seem to be critical points of greater importance. Although the habit is destroyed by the gross lesions, and although such lesions may produce abnormalities in locomotion, the animals are found to be able to relearn the habit, and if the destruction has not exceeded 50 per cent of the cerebral hemispheres, at a normal rate. In some instances the operated animals appear to learn faster, but this has been interpreted as due to the altered locomotion patterns which affect the particular performance[1] rather than as a general improvement in capacity to learn. For example, in one case the operated animals were more apt to step upon a platform (crucial to successful learning) than the normal animals, who usually jumped over it. If the lesions are made in the posterior half of the cortex, retention of the habit is not disturbed. Rats that relearn the habit *after* the destruction of frontal tissue retain the habit after further destruction of the cortical tissue.

These facts seem to indicate that the frontal area is a critical segment of the neural arc. In spite of the fact that impulses may be routed through other areas[2] when this area is destroyed, the disappearance of the habit with frontal ablation indicates that the frontal area is normally involved. The fact that further cortical losses do not again impair the habit suggests that the shift has been made to subcortical levels. This much support is given to the concept of vicarious functioning, since these levels do not possess the traces normally. The evidence upon localization within the frontal lobe is not crucial, being largely negative in character (with the exception noted later.) No finer localization of the trace has been demonstrated.

SIMPLE DISCRIMINATIONS.—The experimental animals may be assigned a simple discrimination task, more obviously dependent

[1] Lashley has shown that slight variations in the task will yield different results. Tearing a strip of paper with teeth or paws, pulling a handle, pulling a chain, proved harder for the operated animals; but pushing a lever, depressing a rod and then stepping on a platform, proved as easy for the operated as for the normal animals. When a lesion decreases the likelihood of appearance of a particular act, learning rates will be slowed, although the habit may still be within the animals' capacity. Lashley, K. S. Studies of cerebral function in learning. XI. The behavior of the rat in latch-box situations. *Comp. Psychol. Monogr.*, 1935, 11, 5–42.

[2] The descending paths which originate in the motor area are not the only descending paths. Both frontal and posterior areas contain cells which make connection with lower centers.

upon one sense area. Thus, rats may be trained to take their food in a lighted alley, and to avoid a dark one. When the habit is established, lesions in the occipital lobe will destroy it. Again, the animals can reacquire it, and if the lesions do not involve more than 50 per cent, learn it at a normal rate. Other lesions (outside the visual area) do not disturb the simple discrimination. Again, lesions produced following the relearning do not affect the reacquired habit. The amount of loss of the habit is roughly proportional to the extent of the lesion. In all probability this is because the larger lesions are more likely to invade the striate area where the ascending optic tracts reach the cortex.[1]

These facts indicate that the visual cortex is a crucial segment of the tracts involved in a simple visual discrimination habit. Destruction of this area clearly does not destroy vision, for the habit can be reacquired. Thus, just as movement is possible without the motor area, vision is possible without the visual area. The fact that further cortical losses do not again impair the habit again suggests a shift to the subcortical levels. Both the problem box and the discrimination results show clearly that the destruction of an area which is normally involved in a specific habit may not amount to a destruction of the capacity to reacquire that same habit.

More Complex Tasks.—A more complex task may be given the animal. Instead of the problem box, the rat may be confronted with a maze with several turns, blind alleys, etc. Although such tasks involve both receptors and the musculature as do the simpler tasks, the operative procedures do not reveal any critical, nodal points. The destruction of the habit rather closely parallels the amount of tissue lost, and does not seem to depend upon any one area. Correlations between the extent of the lesion and the destruction of the capacity to relearn the habit (as high as 0.86) also form a second distinction between the results here obtained and those reported for the simpler tasks. Undoubtedly some impairment follows all cortical lesions, but the tasks used in measuring learning efficiency may be so simple that the impairment is not revealed. Tests calculated to test the flexibility of the animal's equipment, and the ability to readjust and to reorganize behavior, utilizing past

[1] Wiley, L. E. The function of the brain in audition. *J. comp. Neurol.*, 1932, 54, 143–172. This study shows that similar results are obtained when lesions invade the auditory cortex.

training, show graver disturbances than those which depend upon the more automatic and stable situation.[1]

Likewise, a more difficult sensory discrimination may be utilized. For example, the rat may be required to jump to one platform when a certain visual figure appears, and to jump to another when a different figure appears. Or, instead of the gross difference between light and dark, he may be required to discriminate between two intensities, both of which are well above the threshold. In either case lesions in the visual cortex destroy not only the habit but the capacity to relearn. Pattern vision becomes totally impossible if the cortical areas connected with the temporal retinas (median visual field) are destroyed. The presence of lesions in areas other than the occipital may increase the loss of function; but no other area proves critical.

Interpretation of Results.—How shall we interpret these results? They seem to indicate that tracts which mediate habits rise to the primary sensory areas of the cortex, and from thence spread back to the musculature. This highest loop line is involved in all habits, simple or complex. Destruction of a sensory area (*e.g.*, vision or audition) will destroy sensory discrimination *habits*, and in addition the *capacity* to form new discrimination habits of complex level. However, there are other routes over which simple sensory habits may be built (probably thalamic). The fact that any cortical lesion may impair a complex skill, whereas only very specific ones affect the simpler habits, argues that the more complex skills involve and *require* wider areas.

However, to locate the damage which will destroy a habit and to locate the trace itself are two different things. We do not even know how the motor area functions. This is strikingly revealed in a study of motor lesions in primates.[2] A group of rhesus monkeys were trained to open problem boxes, and then after three months in which retention was perfect both right and left motor areas were removed. The paralysis which resulted quite incapacitated them,

[1] Buytendijk, J. J. An experimental investigation into the influence of cortical lesions on the behavior of rats. *Arch. néerl. Physiol.*, 1932, 17, 370–434.

Maier, N. R. F. The effect of cerebral destruction on reasoning and learning in rats. *J. comp. Neurol.*, 1932, 54, 45–75.

Maier, N. R. F. Cortical destruction of the posterior part of the brain and its effect on reasoning in rats. *J. comp. Neurol.*, 1932, 56, 179–214.

[2] Lashley, K. S. Mass action in cerebral function. *Science*, 1931, 73, 245–254.

but after a period of four months it had cleared so that some motor control was possible again. Although they were not given any training in the boxes in the interim, four months after the operation their habits had returned. Even their methods of solution seemed to be the same. Lashley interprets these findings as indicating that the motor area's function is "facilitative" and "priming" rather than as one of supplying specific traces. When it is functioning normally it holds the musculature in readiness for the pattern of afferent excitation, a pattern capable of traveling over different routes.

Nor is the function of the primary sensory area simply one of receiving and relaying impulses over narrow paths. Another experiment of Lashley's clearly indicates that these ports of entry have a more general function. Animals blinded (eyes enucleated) learned to run a maze without seeing it. Following this, lesions in the visual cortex produced a loss of the maze habit comparable to that shown by normal animals, similarly treated. Likewise their loss in capacity was proportional to the size of the injury, in spite of the fact that the eyes were nonfunctional in the training trials. This further hampers our thinking in terms of direct traces and indicates, rather, a much more massive and diffuse type of cortical action. The sensory areas are thus seen to have a more general function, their presence contributing something in the way of support to the efficient action of other areas, apart from the specific peripheral patterns of excitation which they may relay. It would thus appear that any lesion, wherever located, might be expected to depress the level of cortical capacity.[1]

The Brains of Animals and Men.—"Rats are not men." Assuredly there are both neurological and psychological reasons for stressing the distinction, as does Prof. Herrick in his *Brains of rats and men.* On the one hand, there is the elaboration and differentiation of cortical structures; on the other, the emergence of a plasticity in behavior transcending that ordinarily conveyed by the term "habit." Man's behavior is characterized by an imaginative insight, a pur-

[1] Observations of Dr. Carlyle Jacobsen indicate that monkeys with frontal lesion can solve simple one-latch boxes, previously learned, but may find multiple-latch boxes too difficult. Although all the parts of the activity can be handled singly, the assemblage of the parts and the manipulation of this more complex structure may prove too difficult. Similar observations appear (in the aphasias) with human subjects.

posefulness, a creativeness, a freedom from the slavish routine of habit. Man abstracts, deliberates, and is aware of his acts and their relation to his fellows to a degree achieved by no other animal. In fact, man's appreciation of his uniqueness among the species often makes him loath to accord to the findings of the comparative psychologist any great relevance to human problems. In spite of the great gulf, however, both neurological and psychological, between Lashley's subjects and those who appear in the surgical clinic, there is a surprising correspondence—at least in the main outlines. The functions of the parietal, temporal, occipital, and frontal areas are roughly the same. The most striking difference lies in the greater specialization of cortical function, and in the persistence and gravity of the effects of lesion in man. That is to say, there seems to be less evidence of a capacity for reeducation, less of the spontaneous recovery, and less of the possibility of the substitution of thalamic connections for the destroyed cortical routes. Thalamic functions seem to have been promoted to the cortical level, and in the promotion the thalamus has lost some of its powers.

The Effect of Lesions in the Human Cortex.—Unqualified generalizations fail to express accurately the effect of cortical lesions. As much as 70 cc. of tissue may be removed from the frontal pole of one hemisphere (provided the other half of the brain is undisturbed) without producing measurable motor deficit or lowering of intelligence. On the other hand, a sharply circumscribed lesion of the left frontal area (1½ cm. by 2 mm. depth) may produce a marked aphasia. In general, it appears that the lesions of the left lobe of the cerebrum are much more likely to result (in right-handed persons) in severe motor disturbances (including speech) than those of the right side. We cannot generalize to the extent of saying that the gravity of a defect is proportional to the size of the lesion, for to do so neglects the fact that there are critical or nodal points on the neural routes where small lesions result in total and permanent deficit.

Particularly does this latter emphasis fit the cases of lesions in the human occipital cortex. Patients who have suffered damage to this area not only fail to recover the lost visual function; but they may also lose visual memories (images) and behave very much like one born blind. On the other hand, destruction of portions of the parietal area tends to result in a general depression of function rather than a complete sensory deficit.

Where there is a partial loss of function, the more complex, the newly acquired, and the less automatic acts disappear first. In the case of the parietal lesions, just mentioned, the finer discriminations and comparisons of form, size, and weight will disappear before there is a depression of the sensory elements involved; in fact, the thresholds for the simpler sensory functions may remain undisturbed. Similarly in occipital injuries affecting a portion of the visual area or tissues immediately adjacent to it, the patient may be able to read letters, but not words; or, while the subject is able to "see," he cannot interpret the form, recognize or name the object. Again, as in the aphasias, a patient may be able to speak a word in an automatic setting (*e.g.*, naming the days of the week) without being able to give the same word in answer to a direct question (*e.g.*, "What day is it?"). Or a patient may be able to lick a crumb from his lips without being able to imitate an experimenter in sticking out his tongue. In general, we may say that the patient with a lesion requires greater motivation (he may speak under the stress of emotion and fail otherwise) and a wider supporting situation (he can perform acts in appropriate context but fail when asked to deal with the situation abstractly). Activities which we describe as voluntary, intentional, and abstract suffer most of all; and complex skills which involve the accurate coordination and timing of part movements may fail when each of the latter is unaffected. If we think of our conduction system as a multiple-track transportation system we can see how damage to the system might still permit the flow of a limited amount of traffic in apparently normal fashion whereas under the holiday rush or the demand for special routings the system would bog down completely. And like a traffic system, the nervous "trunk lines" have nodal points, destruction of which will block all traffic bound for points beyond. Thus, much of the human patient's behavior following lesions of the central nervous system represents a partial functioning of a crippled conduction system rather than true vicarious functioning.[1]

When we speak of sizable lesions of the cerebral cortex leaving no measurable deficit we should place the emphasis upon the word "measurable." Often what appears to be a normal performance shows a deficit when examined closely. A patient of the British surgeon Horseley was able to play tennis three years after the removal from the right motor cortex of all the tissue whose electrical

[1] Pieron, *op. cit.*, p. 42.

excitation produced arm movement. Originally there had been a marked motor deficit in the left forearm. But while there had been fair recovery, neither his writing nor his tennis was "up to form." For this reason the student of behavior has to accept with caution all statements about vicarious functioning and recovery following ablation experiments unless these statements are backed by adequate behavior tests. Jacobsen's studies of the effect of lesions in the frontal association areas in primates[1] (in front of the motor and premotor areas) have shown that where adequate tests are applied it is found that a permanent deficit of a rather specific character results. Bilateral lesions to this area did not impair memory for problem-box habits, or for visual discriminations (based on size), nor did they destroy the ability to learn such habits. But when problems were given which depended upon the ability to delay reponses, and to integrate the immediate past with the present in serial patterns, a total and permanent deficit (defying extensive attempts at reeducation) was demonstrated. Control experiments utilizing lesions of similar extent in other areas produced no such results.

Since it is the high degree of development of this foremost portion of the brain which most clearly marks the advance of man (and the higher primates) beyond the neural architecture of simpler animals, there has been a tendency to "locate" the higher moral and intellectual faculties in this region. Today the reaction against phrenology and the faculty psychology is likely to lead us to the opposite extreme of assigning to them only generalized conduction functions, of considering them equipotential with other regions, and of classifying them under the noncommittal heading of "silent areas." The more recent studies seem to call for a balance between these two tendencies, for with adequate tests there are found to be defects both general and specific. Brickner has carefully studied[2] a human subject who underwent a partial bilateral frontal lobectomy. His report indicates that, on the one hand, there was a general change in the character of the patient. He became more boastful, hostile, distractible, and more inclined toward self-aggrandizement. As his

[1] Jacobsen, C. F. Functions of frontal association area in primates. *Arch. Neurol. Psychiat.*, 1935, 33, 558–569.

[2] Brickner, R. An interpretation of frontal lobe function based upon the study of a case of partial bilateral frontal lobectomy. *A. Res. nerv. ment Dis., Proc.*, 1932, 13, 259.

judgment and his ability to carry on more complex and abstract processes fell, his self-confidence (and compensatory defenses) rose. Specifically, he seemed to suffer from an inability to integrate his behavior into temporal patterns, to keep in mind a diversity of items needed for solution of problems. The immediate past seemed to drop away; there was no "storage" and synthesis, as in the normal person. There is thus a rather close parallel between the clinical and experimental findings when both are carefully conducted.

APHASIA.—A brief note on some of the problems connected with the study of aphasia[1] may serve to illustrate the points we have stressed in our discussion of brain function. Consider, for example, the attempt to divide brain functions into two groups: sensory (or receptive) and motor (or expressive). From the time of Broca (1861), who reported a case whose sole difficulty seemed to lie in the expressive-motor phase of speaking, and Wernicke (1874), who reported a case where the disturbance seemed to be one of understanding spoken words rather than in articulation, there has been a tendency to divide the aphasias into two groups: sensory aphasia and motor aphasia. The sensory aphasia was attributed to a lesion lying in the temporal lobe, the motor aphasia to one lying in the premotor area (third frontal convolution) of the left half of the cerebrum. Clinical facts seldom fit such a neat dichotomy of function, however, and the studies of the lesions (where these have been carried out) have not given clear-cut support to the localization hypothesis.

The classifications of the disturbances of the language function which result from cortical injury are *behavior* classifications, and in the present state of our knowledge cannot be correlated with narrowly localized lesions of the brain. Head[2] distinguished four types of disorder: verbal, syntactic, nominal, and semantic aphasia. The *verbal* type is shown in pronounced disability in articulation, and at first glance one is likely to regard it as a motor difficulty. Words are slurred (*diff-ulty* for difficulty, *tenical* for technical, *claration* for declaration), or the patient may be limited to a few words (his own name, oaths, automatic word sequences). While in general his understanding does not seem to be disturbed, as soon as instructions

[1] Aphasia may be defined as a disturbance of the language function (speaking or understanding) as a result of cortical lesion.

[2] Head, Henry. *Aphasia and kindred disorders of speech.* New York: Macmillan, 1926.

grow complicated ("Put out your tongue and raise your right hand") he begins to show signs of confusion. As he reads connected passages he frequently stops, retraces his course, seemingly forced to go back and build up the structure of his thought again. The one fact which most clearly marks this as an expressive-motor type of defect is the subject's awareness of what he wants to say, an awareness which frequently exceeds his execution. He may select the correct printed card when he is unable to articulate an answer, or he may indicate by signs, spelling, what he cannot express. (One is reminded of Sherrington's chimpanzee who seemed surprised when the paralyzed arm failed to respond, and who was able to substitute the other (untrained) hand.)

The *syntactical* type of aphasia shows both marked disability in understanding speech as well as slurring, faulty grammar and sentence construction, transpositions. Speech is more disordered than blocked, and the patient is commonly untroubled by his mistakes. His difficulties appear on both expressive and receptive sides. He seems undisturbed by his disordered speech and if repeatedly corrected is reduced to complete confusion. On the other hand, his *comprehension* of the meaning of single words is always superior to his ability to *use* them as names, especially in organized speech. We seem to be dealing with a *level* of disorganization rather than with a deficit that is purely motor or sensory.

Nominal aphasia is characterized by the inability to name objects or qualities, and affects both production and reception of speech. The patient may be able to handle practical situations satisfactorily but be unable to talk about them (*e.g.*, a house painter could mix paints correctly, but was unable to name the color he desired). One of Head's patients could play checkers and dominoes, but found bridge impossible.

Semantic aphasia, as described by Head, seems close to a general defect in intelligence. Reactions to simple directions and simple articulation do not suffer; but in longer statements speech may trail off as though the person had found the more complex structure too difficult, as though he had forgotten what he wished to say. So, too, when the items of the complex command are understood, the larger meaning and significance of the action is missed. He may name the items in a cartoon, but fail to grasp the meaning of the drawing. His own drawing is disordered (in a plan of the room the furniture is misplaced) and he is unable to draw spon-

taneously. Frequently he is disoriented and unable to find his way about. He can count and name coins but may not know their relative values.

Beyond the greater vulnerability of the left lobe of the cerebrum (of the right-handed patients) there is little that seems positive in the way of localizing the speaking-symbolizing function. There are vulnerable areas from the premotor cortex to the occipital pole but we cannot speak of a "language" center, nor can we correlate the different clinical types with sharply defined areas. We find the same distinction between the automatic and voluntary acts that we have noted previously. For example, the simple word "yes," given in response to a question involving deliberation and choice may be much more difficult for a subject to pronounce than a lengthy, stereotyped oath. Weisenburg and McBride report[1] that one of their patients, whose speech "was extremely limited and hard to understand because of difficulties and errors in the formation of words . . . one day startled the examiner by saying suddenly and clearly: 'Shut de door . . . izz a draught at my leg!' "

Concluding Remarks on Cortical Functions.—At the risk of repetition we may emphasize these points:

1. Just as the faculties of the phrenologists have given way to the more precise physiological descriptions of the present day, the attempts to localize judgment, volition, and the higher moral and intellectual functions in specific cortical areas is now seriously questioned.

2. In the reaction against the localizationists and in the attempt to interpret the puzzling phenomena found in animal ablation experiments (vicarious functioning and reeducation) emphasis upon the equipotentiality of the cortex may have swung to the opposite extreme. The specialized functions of the ports of entry (*e.g.*, vision, hearing, etc.), as well as the unique contribution of the frontal poles, seem well established.

3. Instead of mapping these areas as "sensory," "motor," or "associational" in function, we will do well to think of all of them as sensorimotor in character. It is the brain-as-a-whole which initiates action, and then always at the behest of an incoming stream of stimuli. What we have found in ascending from the simpler spinal to the complex cortical levels is a hierarchy of sensorimotor

[1] Weisenburg, Theodore, and McBride, Katherine. *Aphasia*, p. 149. New York: Commonwealth Fund, 1935. Reprinted by permission of the publishers.

connections—the simple reflex, the reciprocal action at a segment, the brain-stem and cerebellar postures which involve the whole trunk, the connections at the thalamic level which bring in the pervasive autonomic reflexes (and simple habit responses), the automatic action (involving the cortex), and finally, the conscious, intentional, purposive pattern of action which involves the entire, alert (tensed) organism and while pointing into the future integrates the present and the past. While in some cases we have located the damage which destroys a function, we are no longer inclined to place the function at the site of the injury. The more adequate our physiological knowledge the less need shall we have for the ancient anima, or any of its modern descendants, the controlling centers.

4. Paradoxically, we have located the damage which destroys habits, but we have as yet failed to find specific tracts which mediate these same habits. Whatever the nature of the traces is finally found to be, they now seem to be of a type which can maintain functional identity though employing different (though possibly anatomically related) channels. Although the removal of the occipital cortex may destroy all the finer visual-motor discriminations, *within this area* there may well be an equipotentiality (and vicarious functioning).

5. There is strong evidence to the effect that each portion of the cortex has both a specific and a general function. What we call the visual area seems to contribute its share to all complex, higher level, activities. Such a view helps us to account for the fact that clinical literature abounds in instances wherein diverse effects are observed from similar lesions, and similar effects from diverse lesions. In addition to the physiological-anatomical aspects of an activity, we need an analysis of such terms as "difficulty of the act," "complexity," "automatic" character, for these terms point to important aspects which, along with recency of acquisition, seem to determine the effects of lesions.

6. The knowledge of cortical function must be regarded as *in process.* We are on the way toward adequate experimental techniques, and the uncontrolled and often incomplete clinical studies are being rapidly supplemented by more accurately planned and executed experimental procedures.

We have lost some of the assurance and dogmatism of the early phrenologists and have extended our physiological interests beyond the conduction-transmission mechanism. If the nervous system is

essentially a transmitter and integrator, it now behooves us to turn our attention to those other portions of the organism involved in every act. The phenomena we call "mental," we now believe, are functions of the organism-as-a-whole, and in our next chapter we shall examine those structures which supply the stream of impulses carried by the conduction system.

CHAPTER III

RECEPTORS

The Triggers Which Initiate Activity

Introduction.—Our examination of the animistic beginnings of psychology led us into the intricate structures of the nervous system. Examined in the light of modern physiology, the nervous system no longer seems to be the dwelling place of the anima. Rather, it provides an intricate and highly efficient conduction network, integrating the receptor surfaces with the responding musculature and causing remote parts to act together in unified patterns of activity.

The activity within the cells of this conduction system, which initiates activity in muscles and glands, is in turn instigated by the receptors lying at the afferent ends of neural pathways. In no case does the physiologist find reason to think of the nervous system as a prime instigator of action. Instead, he looks to the sensory triggers which set up these waves of electrochemical stimulation as the first causes of the organism's activity. The neural arc merely supplies the network through which the neural disturbance can spread to the effector system.

An organism lying quiescent in a stable environmental field might be described as in a state of equilibrium. The forces playing upon it (gravitational, thermal, mechanical, etc.) are neatly balanced by contracted muscle groups, producing a stable posture. Change one of these forces, or introduce a new one, and a readjustment is forced upon the organism—a readjustment which must continue until a new equilibrium is achieved. Some of these readjustments will occur immediately, reflexly, as in the righting reflex of the animal with statocysts. Others take the form of continuous "random" activities which seem poorly calculated to achieve their end, but which persist until it is finally achieved, at least in a favorable environment.

As an example of the latter type of adjustment, consider the behavior of the earthworm, lying quiescent on a moist, darkened

surface. The sudden illumination of the field by diffuse light will set the worm in motion. Although there may be an appropriate darkened shelter near at hand, he has no receptors which can direct him toward it and must continue crawling until by chance he strikes it. Although his movement appears to be random and his solution an affair of "chance," his turns from point to point are undoubtedly regulated by stimuli, both internal and external. In fact, by substituting a bright directional beam for the nondirectional light we can "force" him to turn toward any point in the field, for the earthworm has a reflex equipment which will turn him away from a light source.

With the honeybee, the reflex operates in the opposite direction. With wings clipped, crawling on a uniform surface, he moves directly to a light source. If we coat one eye with an opaque shellac so as to exclude all light, and then stimulate him with an overhead diffuse light, he will circle toward the good eye, turning round and round in a spiral. The lack of balance in the stream of visual impulses has forced this orientation.

Everywhere, throughout the animal kingdom, the story is the same. A chemical stimulus attracts the moth to its mate. A mechanical stimulus sets the tube feet of the starfish in motion. The rising sun sends some marine animals scurrying to the bottom and brings others to the top. Stimuli start, arrest, and guide the movements in their course. The function of nervous tissue, in the meantime, is merely to conduct and integrate, to provide the channels through which the stream of impulses flows.

Internal Stimuli.—If we consider merely these external stimuli, the movements appear forced and the animal is viewed as completely subject to external conditions. But, we may ask, doesn't the animal have anything to say about it? Obviously, he does. The food (chemical stimulus) which activates the hungry starfish is ineffectual when he has just eaten. Apparently there are internal states which must be considered. Some of these we have already considered, in pointing out how the posture of a member alters the sign of a reflex to an external stimulus. Internal receptors within the muscles send a stream of afferent impulses into the central nervous system, which are as effective regulators of activity as those which play on the body surface. Thus, at any given moment, the effect of the external stimulus depends upon the activities already going on within the organism.

And there are other "resident" controls. Metabolic changes within the tissues, secretion of the endocrine glands, distention of the hollow visceral cavities, contraction or relaxation of the walls of the blood vessels shifting the distribution of the blood supply, may either initiate new activities or alter the course of those in progress.

The changes which initiate activity are thus seen to be both external and internal. Though we may think of any given segment of activity as forced, it is clear that the forces are by no means confined to those external to the organism. And if the "vital spirit" which was posited by an earlier generation of biologists is now split up into a multitude of electrochemical conditions and described in physical terms, behavior loses none of its dynamic qualities. The mechanical description of the part activities does not mean that passivity is a characteristic of the whole. Instead, the more closely we examine the tissues of animals the more their bodies appear to be in ceaseless motion; and when we view the activity of the organism as a whole we see that it reacts *into* the environment as well as *from it*.

Limits Imposed by Sense Organ and Effector.—Whether we describe behavior in purely geometrical terms, as consisting of movements of approach or avoidance, or speak of it in valuistic terms, as a "struggle for survival," it will be sharply circumscribed by two factors. On the one hand, there will be the peculiar properties of the effectors, themselves. The rate, strength, and patterns of the responses which are possible for any given animal form will be definitely limited by the physiological properties and structural arrangement of these organs of response. And, on the other hand, these effectors, which can only operate when stimulated, require a set of receptors so attuned that they will respond to the physical changes of the environment.

Neither his musculature nor his receptors have proved sufficient to meet man's needs. Nor are they so highly developed but that superior forms for most items are found scattered throughout the animal kingdom. The mosquito's wings move at a faster rate, the ox has greater strength, the dog a better sense of smell, some birds can see beyond man's spectral limit, and insects hear vibrations to which man's ear is insensitive. Although man's equipment in effectors and receptors is sufficient to grant a bare existence, it is their unified activity mediated by the nervous system that has made

possible the development of something more. He has compensated for his physiological inadequacies with tools; his machines give him a strength, speed, and accuracy which his own equipment lacks. Every sense has been extended by recording devices, most of which translate the physical changes around him into the visual field where his perceptions are most accurate. Even without vision his inventive power could make another and duller sense suffice.

Nevertheless, with all his cleverness and the power to learn from experience he is still bound within the limits imposed by sense organ and effector. We need to explore these boundaries (at least cursorily), for they still impose limits upon man's world.

Receptors in Skin and Muscles

The skin and muscles contain the basic receptor system. Important though the distance receptors (visual, auditory, and olfactory) are in putting us "in touch" with a wider environment, the meaning of the vibrations which they receive ultimately derives from touch. The smooth, sleek coat of the well-groomed horse (physically a pattern of light intensities and wave lengths when it becomes the object of our glance) *means* a certain type of response which contact and stroking would produce. In this sense touch is the educator of all the other senses. Not only is it *primitive* in the phylogenetic scale, but it is the basic point of reference for much of the development of the individual. Before the eyes recognize the mother the infant's lips adjust to her breast, and before the hands reach forth to grasp an object there is a reflex grasping and mouthing of objects-in-contact.

Nearly every cell of that layer of the epidermis next to the true skin (Fig. 25) is supplied with one of the terminal branches of an afferent fiber. So, too, in the dermis proper, in the muscular linings of the blood vessels of the skin and underlying tissues, and in the muscles, tendons, and joints—in short, in every cubic centimeter of our flesh—sensitive terminal endings are ready to report the pressures, pains, warms, and cools which we experience. With our skins we sense objects to be rough, smooth, sticky, oily, heavy. Or, we say that they cause our skin to burn, smart, tickle, itch. And we sense our movements as rapid, slow, tense, halting, smooth-flowing, long, short. We feel the hot mounting flush of anger or shame, the cold chill of fear, the thrill of excitement.

Where do these experiences originate, and what gives each one the stamp of uniqueness? And which (if any) shall we view as

unitary, and which as synthetic compounds? For over a hundred years introspectionists, with closed eyes, have studied the internal events which follow stimulation of skin and muscle tissue. By manipulating and controlling the stimulating conditions, and carefully reporting their experiences, they have arrived at four basic "sensations":—warm, cool, pressure, and pain. To these many would add a separate movement-sense, deep pressure, tickle, itch, and vibration. Some have maintained that warm and cool are but phases of a single temperature sense, and others have urged that pain is simply intense pressure.

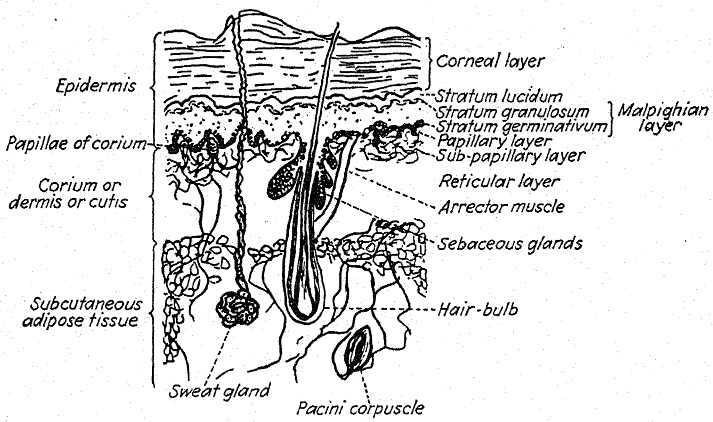


FIG. 25.—Section of the epidermis. Free nerve endings are shown and some of these terminate about the hair follicle. When the hair shaft is moved, these endings are stimulated, yielding pressure sensations. Some believe that the Pacini corpuscle is in some manner connected with the pressure sense, but adequate evidence is lacking. (*From J. P. Nafe. Handbook of experimental psychology, p.* 1044. *Ed. by C. Murchison. Worcester: Clark Univ. Press,* 1934. *By permission of the publishers.*)

This would be very much a matter of taste if it were not for the fact that the unitary "qualities" are supposed to originate from independent skin and muscle receptors; hence it is that the discussion turned finally to more objective questions of fact. Can we demonstrate independent receptors for each basic "quality"? (Obviously, if we can isolate a specialized receiving structure, which alone will produce the quality, we have the best type of proof.) Failing this proof, can we demonstrate that these elements behave independently?[1]

[1] The introspectionist has made use of a third type of proof. He has sought to produce the compounds experimentally by combining the elements obtained by

The Distribution of Sensitivity. *a. Warm and Cool Spots.*—If an experimenter explores the surface of our forearm with a cooled metal cylinder (10°C.) pointed so that a blunt tip of 1.0 mm. diameter touches a limited area at a time, we shall find that as he successively touches a row of points a distinct sensation of cold will "flash out" from some of the spots. At all other points the slight pressure of

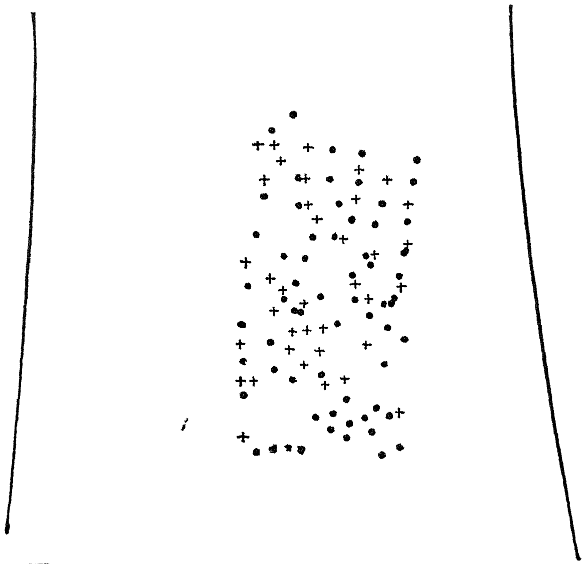


FIG. 26.—Warm and cool spots. The dots represent warm spots found when the surface is explored with a temperature stimulus 41 to 48°C. The crosses are the cold spots tested with a stimulus at 10°C. The area represented is on the volar surface of the forearm. (*After von Frey. From W. H. Howell. A textbook of physiology, p. 119. Philadelphia: Saunders, 1934. By permission of the publishers.*)

the cylinder will be felt, but the difference between the two types of experience is very clear. If the experimenter makes a map of the area and repeats the procedure with a similar warmed cylinder (45°C.) he will find that "warm spots" are reported. These will

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introspective analysis. Thus a combination of cool and pressure can be made to yield a sensation of "wetness," a combination of heat and pain "smarts," and warm and pressure "oiliness." That the method is not altogether satisfactory is apparent from the extent of disagreement. The same problem arises in connection with smell and vision; and in the case of the latter sense confusion is introduced by the fact that it is possible to produce the "primary" colors by mixing together "compound colors."

be fewer in number,[1] react more slowly,[2] and occupy different localities (see Fig. 26). On some body areas these temperature spots are not found, for example, on all of the cornea save the extreme margin.

b. Pressure and Pain Spots.—Similar mapping techniques have demonstrated the existence of pressure spots and pain spots. The number of such spots discovered (as in the case of the temperature spots) varies with the surface explored and the type of exploring stimulus.[3] Minimal stimuli are ordinarily used,[4] in order to confine stimulation to a small area of surface tissue.

A comparison of various surfaces shows that not only is there a difference in general sensitivity, but that the two types of sensitivity are not closely correlated.[5] Thus:

Area	Touch	Pain
Back of hand	28	188
Forearm	16	196
Ball of thumb	135	60

Figures presented by K. Dallenbach. (Boring, Langfeld, *et al.*, *op. cit.*)

[1] Roughly there will be 10 cold spots to 1 to 2 warm spots, and of the former there will be approximately 7 to the square centimeter. These numbers vary with the surface explored, the method of applying the stimulus, and the temperatures used.

[2] The reaction times reported are: warm 0.5 sec., cool 0.3 sec.

[3] The numbers reported vary widely, for example, for pressure from 25 per square centimeter (von Frey's observation on forearm) to 300 per square centimeter (Goldscheider, similar area). The "pain spots" require greater intensities (1,000 times that for pressure) and are described as more numerous. Dallenbach estimates their average distribution as 175 per square centimeter as against 25 per square centimeter for pressure. Cf. Dallenbach, K. Chap. 7 in *Psychology, a factual text-book*. Ed. by E. G. Boring, H. S. Langfeld, H. P. Weld, *et al.* New York: Wiley, 1935. An excellent summary of the experimental facts and relevant theories is given by Nafe, J. P., in the *Handbook of experimental psychology*. Ed. by C. Murchison. Worcester: Clark University Press. 1934, Chapter 20, The pressure, pain, and temperature senses.

[4] For pressure: fine hairs or glass threads mounted on a small stick. For pain: stiffer bristles or fine needles.

[5] An area inside each cheek (opposite the molars) is relatively insensitive to prick or electrical stimulation, and although the stimuli are felt as pressure the subject reports no pain. Conversely, the cornea and conjunctiva are so sensitive to pain that it is very difficult to arouse mere pressure response. The areas in question are not confined absolutely to one mode of sensitivity, however, for

Again, as in the case of warm and cool, reaction times differ; that for pain being much slower (0.46 to 0.88 sec.) than pressure (0.12 to 0.27 sec.).

Skin Receptors.—It would appear that, having proved the independence of these basic qualities and having located the most sensitive points of origin upon the skin surface, the subsequent task of making a microscopic description of the specialized sensory endings themselves would be comparatively simple. This has not proved to be the case. Although the skin is richly supplied with nerve endings, both free and capsulated, excision and examination of the tissue underneath the special spots has failed to yield the crucial data.

It was discovered, however, that pressure spots and pressure sensitivity were associated with the distribution of hairs in the skin surface. A spot about 1 mm. from the point of emergence of the hair shaft (on the "windward" side) and the hair shaft itself prove to be especially sensitive. Thus, shaving an area raises the limen from 2 to 36 mg.[1] Microscopic examination of the hair follicle and neighboring tissue shows that branches of the fibers which terminate as free endings in the epidermis form a ring about the hair shaft. A stimulus applied to the pressure spot above this ring will thus stimulate these endings by compression, and at the same time move the hair shaft and the surface skin about its point of emergence. Likewise, pressure upon the hair itself will activate these endings and deform the skin. (A stick deeply thrust into a mass of dough and moved back and forth would similarly deform the surface of the dough. Like such a stick, the hair shaft behaves as a lever of the second class.) That this interpretation of the action of the hair as a pressure organ is correct was neatly demonstrated experimentally by mounting artificial hairs on hairless areas. Subjects could not distinguish sensations so aroused from those originating from the normal hair shaft.[2]

It would appear, then, that the stimulus for the pressure sensation is deformation of the skin. The tensions so created act upon the free

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biting the cheek in this area causes vivid enough pain. A few investigators report success in eliciting pressure alone from cornea and conjunctiva.

[1] Starling, E. H. *Principles of human physiology*, 5th ed., p. 481. Ed. and rev. by C. Lovatt Evans. Philadelphia: Lea, 1930.

[2] Stetson, R. H. The hair follicle and the sense of pressure. *Psychol. Monogr.*, 1923, 32, No. 3, 1–17.

nerve endings. The hair is merely an accessory (lever) making the deformation easier. Since minimal stimuli are employed in exploring the surface, the pressure spot merely represents the most vulnerable areas, or points of concentration, of such free endings.[1]

Free nerve endings also mediate pain. Apart from the direct experimental demonstration, there is the fact that the cornea contains free nerve endings only, and this area is notably sensitive to pain. In the absence of known differentiation, it appears that these free endings carry two types of nerve impulse, and that it is the *pattern* of impulses set up by the stimulus, rather than a particular type of receptor, which determines the difference between pressure and pain. Thus, weak and momentary stimuli which yield pressure will—if continued and intense—produce pain.[2]

There is considerable experimental evidence which points to the afferent endings within the smooth-muscle walls of the skin blood vessels as the point of origin for warm and cool. Two types of response are initiated in smooth muscle by direct temperature stimulation: relaxation (warmth) and contraction (cold). These may be studied in excised muscle or in an area whose neural connections have been severed. It is also noteworthy that the reaction times for these responses fall within the limits for warm and cool in the temperature experiments. (The values for smooth-muscle range between 0.2 and 1 or 2 sec.) Moreover, there are some interesting parallels between the action of smooth muscle and our own reactions to temperature change.

The tissues of the skin normally maintain a temperature of 33°C., and a zone extending 0.5° on either side of this point may be called the *physiological zero*. From 33.5° to 45° stimuli feel warm, but at 45° the experience changes to heat in which a pain element seems to be added, this element increasing until at 50 to 52° pain alone is felt. Below 32.5° cool changes to cold at 12°, where the pain element again appears, and at lower temperatures (*ca.* 3°) pain alone remains. Similar critical points are observed for smooth muscle:

[1] Von Frey, in attempting to account for the pressure spots found in hairless areas (*e.g.*, palm of hand and sole of foot), found that the number of pressure spots often approximated the number of Meissner corpuscles (oval bodies about 1/300 in. in length, and supplied with nerves, plentifully distributed over palms and soles); but their comparative rarity in the regions of the lips, tip of tongue, mamma, and genitals, make this type of evidence dubious. At least they cannot be regarded as the sole organs of pressure.

[2] Nafe, *op. cit.*

the relaxation in the warmed muscle changes to spastic contraction when the temperature reaches 45 to 50°, and the steady contraction passes into severe constriction. Severe constrictions of the muscle also replace the more steady tone when temperatures reach the lower extreme. The similarity in the muscular states at the two extremes of temperatures is strikingly paralleled by the confusion often found in the temperature experiment when the subject's report of "cold"[1] is called forth by the contact of the warmed cylinder (over 45°). The extremes of hot and cold are often indistinguishable.[2]

Thresholds, Adaptation, "Afterimage."—The stimulus which arouses a response in these afferent endings (pressure, thermal, injury to nerve fiber) must be of a certain intensity. This value is called the *threshold*, and all intensities below this level *subliminal*. Successive application of subliminal stimuli may produce a reaction (summation), but the successive stimuli must fall within certain intervals; otherwise a recovery process cancels their effects. Similarly, external changes must occur at a certain rate if they are to operate as effective stimuli. Thus, a nerve may be crushed without inducing a reaction if the pressure is applied slowly enough.[3] And we adapt to the temperature about us: immersing the forearm in a warm-water bath so alters the physiological zero that higher temperatures are necessary to induce a perception of warmth, and a previously neutral stimulus feels cold. Or, if one hand is adapted to a warm medium, the other to cold, and then the two hands thrust into a common neutral (33°) medium, the latter medium feels warm to one hand and cold to the other. Even pain shows this phenomenon of adaptation. Following the removal of the stimulus the sensation persists for a brief period. This *afterimage* is commonly attributed to continuing changes in the receptor. Thus pressure

[1] This "paradoxical cold" has been commonly attributed to the arousal of some hypothetical cold receptor by an inadequate stimulus, but the mechanism of such action has hitherto remained obscure. The fact that, depending upon the state of the muscle and the mode of application of the stimulus, mechanical stimuli occasionally elicit either contraction or relaxation of smooth muscle helps, at least, to clarify the problem.

[2] A device which has often been employed in initiation ceremonies depends, in part, upon the ease with which these extremes are confused. The blindfolded novice who is to be "branded," and who has been prepared by a preliminary ritual of heating the iron, etc., is touched by ice-cold metal. His experience is quite complete.

[3] Nafe, *op. cit.*, p. 1041.

will be felt until the skin, deformed by the stimulus, returns to its normal position (or until the rate of change falls below the threshold).[1]

Receptors in Muscles, Tendons, and Joints.—An injury to a nerve may render an area of the skin surface completely anesthetic to all weak stimuli. Severe pressure, however, may be felt though not sharply localized. Similarly, the active contraction of the

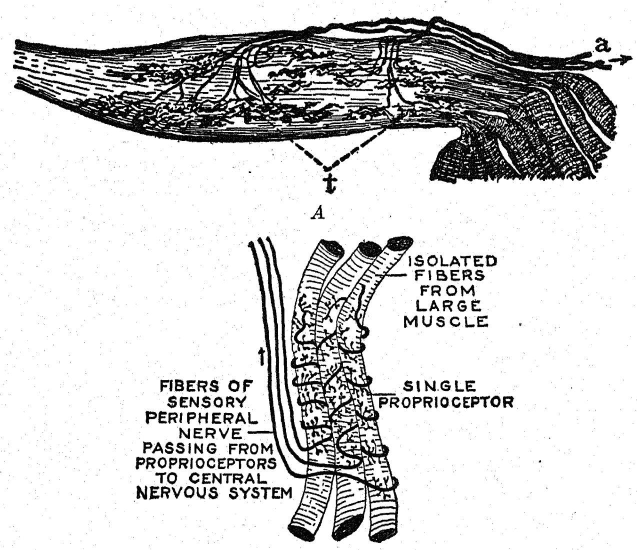


FIG. 27.—Proprioceptors in muscle and tendon. *A*. Endings of afferent nerve (*a*) spreading over tendon. (*From G. L. Freeman. Introduction to physiological psychology, p.* 64. *New York: Ronald,* 1934. *By permission of the publishers.*)
B. Proprioceptor fibers winding spirally about muscle spindles. (*From H. C. Warren and Leonard Carmichael. Elements of human psychology, p.* 135. *Boston: Houghton Mifflin,* 1930. *By permission of the publishers.*)

underlying muscles is felt. Both deep pressure and sense of movement are aroused by the stimulation of afferent endings which penetrate the striped muscles (see Fig. 27). Again, the difference in subjective impressions (deep pressure and active contraction) will depend upon a different *pattern* of innervation.[2]

[1] When one looks at a skin surface under the microscope, as a liminal tactual stimulus is applied (von Frey hair), one can see that the stimulus point depresses the skin for a considerable area much as stick thrust against a pillow.

[2] Cf., too, the contrast in subjective experience between pressures (through the abdominal wall) activating endings in stomach muscle, the contractions felt as hunger, and the cramps producing acute gastric pain. The frequencies of the waves constituting the impulse and their distribution over centripetal conduction

In addition to the afferent endings embedded in the muscle tissue itself there are endings in the tendons which attach muscle to bone, and in the membranes about the joint. It is also true that the endings in the skin[1] (which is stretched as a member turns about the joint) are an important adjunct to this muscle sense. In fact, though the receptors of the skin and muscle are anatomically separate, they are in continuous functional cooperation. As we palpate a surface in estimating its consistency, as we heft a weight, muscle contractions and skin pressures combine in determining our estimates. The blindfold man shuffling his feet forward with hand extended is "feeling" with both muscles and skin surface. The shock of the unexpected obstruction acts upon the external receptor surface and upon an active postural set.

The role of kinesthetic impulses in controlling behavior has received emphasis in an earlier discussion (cf. page 43, tabes dorsalis). The skin provides a similar essential stream. Our clumsiness in manipulating an instrument, or in tying a knot with gloves on, is due to a loss and distortion in the sensory controls. We find that the soft rubber caps which are placed over typewriter keys throw out our coordinations as typists. Even the loss of the auditory clicks as we transfer to a noiseless machine is disturbing at first. Our stream of movements is started and stopped by the sensory stream, and demands constant support and correction from the receptors. At the same time the musculature supports and directs the sensory surfaces *into* the environment. Like a patrol sent out by the troops in a beleaguered city, the receptor surface sends back communications which alter the disposition of forces in the city, and the reallocation of forces may involve a recall of the patrol.

Visceral Receptors

In addition to the stream supplied by the voluntary (striped) muscles—the red, striated muscles which move the body's levers through space—there is a continuous (yet varying) pattern of impulses arising from the smooth musculature. Arranged in sheets, tubes, and pouches, smooth muscle—innervated by the fibers of the autonomic system—carries on the vital processes in automatic

paths vary, and it is upon such differences in the physical character of the stimulus that differential responses must hinge.

[1] If the skin of the joint surface is made insensitive by a local anesthetic, the subject's accuracy in estimating his movements falls.

fashion; but while these reactions are reflex in character, we are not insensitive to them. Like the surface blood vessels, the smooth musculature is everywhere supplied with afferent endings and periodically the viscerally initiated stream rises to the foreground of consciousness. At all times this visceral stream will affect the general tone of the striped muscles and many of our fluctuations in mood parallel the state of our smooth muscles. The slang expression, "no guts," used to describe a lack of stamina—an attitude of helplessness in the face of a situation calling for action—might be given a physiological translation; for the attitude is characteristic of a complete inhibition of the normal smooth-muscle tension which supports our postures and activities.[1] Experimental exploration of stomach and rectal surfaces shows them to be sensitive to mechanical, thermal, electrical stimuli. For the most part, however, it is usually the stretching (from distention) or the spastic contraction of the visceral muscle itself which reminds us of its presence. The lump in the throat (globus hystericus) turns out to be a spasm of the muscles of the esophagus. Hunger, nausea, feeling of fullness, and gastric pain originate in the stomach muscles, and symptoms duplicating those of gastric ulcer are sometimes traceable to spastic contractions of the duodenum.[2] Similarly, the circulatory, excretory, and reproductive systems give rise to characteristic patterns, varying most widely in their subjective aspects. Viewed physiologically, these afferent streams originate in patterns of pressure upon afferent endings within the smooth musculature, patterns varying in locus and intensity. Viewed subjectively, the resultant experiences might be said to vary *qualitatively* (from, say, gastric pain to sexual desire). The more or less common character of their source suggests that their "meanings" and unique "qualities" must arise from the reactions which they evoke in the rest of the musculature. Frequently their effects seem to be quite diffuse[3] and nonspecific, felt as a general tension rather than as an impulsion toward a definite line of action, and at other times consciousness seems absorbed with the goal of action (and the individual need not be aware of the source

[1] The fascist third-degree method (heavy doses of castor oil) is thus seen as calculated to destroy the prisoner's stamina through a direct attack upon his "intestinal fortitude."

[2] The first division of the small intestine beginning at the pyloric end of the stomach.

[3] In this connection it is interesting to note that the same muscle is active in nausea, hunger, and gastric pain.

of his preoccupation). We shall return to this problem in later discussions (motivation, learning, emotion, the unconscious).

Many of the alimentary canal states can be fairly well localized, but the clinician learns to discount (and correct) his patient's localizations of visceral pains. In general, the stimulation tends to be referred toward more sensitive and better trained areas (*e.g.*, esophagus to mouth). Often, internal disorders are accompanied by cutaneous pain and tenderness in surface tissues, remote from the affected organ. Thus, an inflamed hip-joint structure may be accompanied by a hypersensitiveness of the skin surface on the inside of the knee, or uterine disorders by a sensitiveness in the surface tissue of the small of the back. These skin pains, unaccompanied by any pathology of the external tissue, are described as "referred pains." Herrick attributes them to the fact that the afferents from the viscera enter the spinal cord at the point of entry of the remote surface afferents,[1] and hence activate similar responses.

Chemical Receptors of the Nasal Cavity

An area of *ca.* 500 sq. mm. located at the top of the nasal cavity, and marked a yellowish or brownish cast, contains olfactory cells which react to air-borne chemical substances. Although only eddies from the main breath current reach this uppermost chamber, remarkably small quantities of odorous material in the inhaled air produce perceptible effects.[2] Beneath this pigmented area are found the true olfactory cells. From an ovoid cell body a rodlike process extends to the surface of the epithelium (see Fig. 28) and terminates in a tuft of from 2 to 12 hairs which lie in the mucus of the nasal cavity and are believed to furnish the reacting surfaces.

At the other end of the cell an axon passes upward through the interstices of bone to connect with the olfactory bulb. Here relaying cells give rise to fibers which pass to the brain.

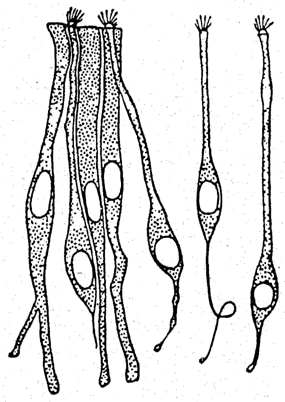
One of the most noticeable characteristics of the olfactory sense is its rapid fatigue, or adaptation. If inhaled air is drawn over cotton saturated in iodine, the odor will disappear within 4 or 5 min. At

[1] Herrick, C. J. *An introduction to neurology*, 2d ed., pp. 253–256. Philadelphia: Saunders, 1921.

[2] 1/460,000,000 mg. of mercaptan in 50 cc. of inspired air could be detected. A mere 200,000,000,000 molecules! Crozier, W. J. Chap. 19, Chemoreception, *Handbook of experimental psychology*. Ed. by C. Murchison. Worcester: Clark Univ. Press, 1934.

the same time other odors may still be effective, thus suggesting that the adaptation is due to the exhaustion of a specific substance. Or a more complex substance may be used, and as adaptation progresses there will be pronounced changes in the quality of the odor. A pleasant, flowery odor may change to one distinctly less pleasant.

These facts provide a basis for the classification of odors. Henning has suggested a list of six (flowery, fruity, resinous, spicy, putrid, and burned). Schematically represented, these may be conceived as the



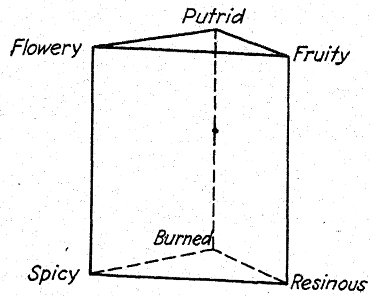


FIG. 28. FIG. 29.

FIG. 28.—Olfactory cells. The true olfactory cells have from six to eight hairs at their tips. The other cells have a supporting function. (*After von Brunn. From G. H. Parker. Smell, taste, and allied senses in the vertebrates, p.* 31. *Philadelphia: Lippincott,* 1922. *By permission of the publishers.*)

FIG. 29.—Olfactory pyramid. Diagram illustrating proposed scheme for classifying odors. (*From H. Henning. Der Geruch. Zeit. f. Psy. u. Physiol der Sinnesorg.,* 1915, 73, 254. *Leipzig: Barth. By permission of the publishers.*)

six points of a prism, with various "compounds" lying on the surfaces (see Fig. 29).

Although such a classification provides a descriptive vocabulary, and indicates real similarities in odor-producing properties of substances (even affording some basis of prediction), it leaves the fundamental physiological questions unsolved. There are no exploratory studies which have located separate receptors, and there is no complete account of the fundamental chemical processes involved. We cannot even say that this classification bears any necessary relation to either physiological or chemical process.[1]

[1] Zwaardemaker has proposed *nine* groups: (1) ethereal (fruit ethers, beeswax, aldehydes, ketones); (2) aromatic (camphor, spice, anise, lavender, lemon, rose, almond); (3) balsamic (jasmine, orange, lily, vanilla); (4) ambermusk; (5) leek (H_2S, asafetida, fish); (6) burning (tobacco smoke, creosol, benzol); (7) hircine

In general, the fifth, sixth, and seventh groups in Mendelyeev's classification of elements yield the most odorous substances. Also, substances with more complex molecules, higher specific gravity, offer more intense olfactory stimuli. Marsh gas (CH_4) is odorless, ethane (C_2H_6) has a faint odor, and propane (C_3H_8) a distinct smell. McKendrick suggests that to produce an odor a substance should have a molecular weight at least fifteen times that of hydrogen.

The failure to understand the basic nature of olfactory reception leaves many phenomena in this field obscure. For example, there is the cancellation effect exerted by certain odors upon each other. The cancellation is seldom complete, but the intensity of the components is noticeably weakened.[1] Such cancellation is to be distinguished from the masking effect of a stronger odor and is most easily demonstrated at low intensities. The same neutralization effect is produced when the two substances are allowed to diffuse through separate tubes, one to each nasal patch.

Marked individual differences in olfactory sensibility are noted. Not only is there great variability in general sensitivity (colds, smoking) from time to time within a single individual and between individuals, but some individuals are unable to detect such odors as vanilla, violets, mignonette. There are also defects which accompany certain pathological conditions, but neither these cases nor the study of individual differences has thrown any light on the question of specific receptor mechanisms.

Smell might be called a vestigial sense. In the lower animals (*e.g.*, insect, fish, dog) the receptors are more delicate, and both the central connections and the behavior of the animals show it to be an important regulatory sense. In the fish the olfactory sense might be said to provide "taste at a distance" and the food getting of some species seems largely regulated by it. Insects recognize their nest mates through odor. In the dog a keen sense of smell compensates for very indifferent vision.

In man, its function as a distance receptor is largely usurped by the eye and the ear. True, it is able to prepare the digestive appara-

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(cheese, sweat, sexual odors); (8) repulsive (opium, bugs); (9) nauseating (feces, putrefaction). The fact that these classifications differ in many ways from Henning's suggests that the technique of classification is not capable of revealing the primary physiological process.

[1] Musk and oil of bitter almonds, iodoform and volatile, afford examples of contrasting pairs.

tus (saliva and gastric juice) in advance of the more adequate tastes, and it warns us of the presence of a variety of objects, both pleasant and repulsive—thus initiating through associated mechanisms preparations (searching or avoiding) for the objects-to-come. It operates, however, as a general "tensing" stimulus, and is poorly localized. The "meanings" of the olfactory stimulus are largely acquired, and hence subject to wide modifications.

Chemical Receptors of the Mouth Cavity

The taste organs are specialized, chemically sensitive cells scattered over the tongue, upper pharynx and gullet, soft palate and

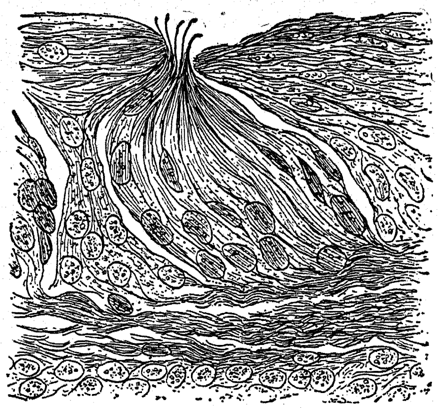

Fig. 30.—Section through taste bud of foliate papilla of rabbit, showing gustatory pore and gustatory cell. (*After Rauvier. From P. N. Mitchell. General physiology, p.* 182.)

(at least in children) the inner surface of the cheek. From 2 to 12 cells, grouped in an oval cluster, form the "taste bud," and "taste hairs" on the ends of these cells project into a pore which opens upon the surface (see Fig. 30). Nerve fibers ending upon the surfaces of these cells pass over at least four pathways to the higher centers.

On the tongue these buds are found in connection with the papillae (see Fig. 31). From 7 to 12 of these papillae (vallate) may be seen at the back of the tongue, forming an inverted V (or chevron), each like a low hillock surrounded by a circular depression. In the walls of this depression are the pores opening into the taste buds.[1]

[1] Recent estimates indicate as many as 250 buds to the papilla.

Other buds are near the bright red fungiform papillae, most numerous at the tip and sides of the tongue.

Chemicals in solution may thus come in direct contact with the receptor cells, initiating salivary secretion reflexly, and the series of changes which we experience as taste sensations. Most of the tastes which we experience are compounds of tactual, olfactory, kinesthetic, and even auditory stimuli. The tasteless character of our food when the nose is blocked is a common experience. Without odor there is little difference between the taste of an onion and that of an apple.

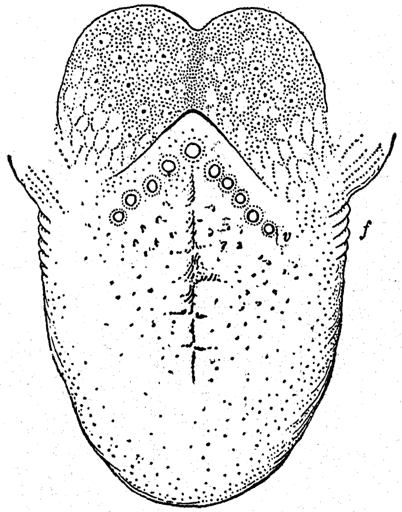

FIG. 31.—Dorsal view of the human tongue. *f*, foliate papillae; *v*, vallate papillae. (*From G. H. Parker. Smell, taste, and allied senses in the vertebrates, p.* 112. *Chicago: Lippincott,* 1922. *By permission of the publishers.*)

Spices may add pain and warmth sensations in addition to their odor, the consistency of the food will give a characteristic pattern of pressure, and the crunch or crackle of crisp pastries and breakfast foods add an auditory component. With appropriate controls to eliminate these accessory qualities, taste sensitivity is found to possess but four qualities: salt, sour, sweet, and bitter.

While it has not been possible to isolate separate buds or cells which respond to but one of these, separate receptor organs are commonly assumed. Some drugs affect the tastes differentially, but lacking an adequate picture of the underlying chemical processes, these results are difficult to interpret. There is some evidence of differential sensitivity in the different portions of the tongue:

sweet is most clearly perceived at the tip (least at the base), bitter at the vallate papillae at the back, acid at the sides, salt is evenly distributed. And as with odors, individual differences are reported. A substance (phenylthiocarbamide) may taste bitter to some and sweet or indifferent to others. Some believe that these differences are inherited in a simple manner.

Attempts have been made to associate the taste qualities with the chemical properties and molecular structure of their adequate stimuli, but with little success.

The phenomena of contrast, adaptation or fatigue, and summation may be demonstrated in this sense field as in others. Stimuli applied simultaneously to different parts of the tongue may reinforce each other. Thus, if salt solution is applied to one side and a sweet—in subliminal concentration—is applied to the other, the otherwise subliminal stimulus is noticed. Similarly, successive contrast appears when after holding salt water in the mouth, distilled water takes on a slightly sweetish taste. Adaptation through prolonged stimulation may destroy the sensitivity to one class of stimuli without affecting others, suggesting the depletion of a receptor substance.

The Ear

The ear might be called a "social" sense, for through it the movements of our fellow man are made audible. Before man communicated with written signs, and even in that imagined period when he was limited to emotional cries, his uttered sounds made other bodies vibrate in response. Even with perfect vision, the deaf person suffers an isolation not felt by the blind, for he misses the delicate nuances of expression, the accents, inflections, and emotional overtones of speech, which reveal meanings which gestures only partially express. Without the medium of sound we resort to the coarser caricature of pantomime (cf. the early motion pictures) or the derived (and more abstract) written symbol. The art of music, which appeals so directly and so powerfully to our emotions, is an impressive illustration of the value of this sense in human culture.

In biological terms, the ear is a distance receptor, freeing the organism from the imperious dominance of the immediately (and tactually) present stimulus, and providing warning signs, orienting stimuli, which pave the way for the object-to-come.

The External and Middle Ear.—Physiologically and mechanically, the ear is a device for translating air vibrations into nerve impulses. The tympanum (eardrum) and bones of the middle ear provide a receiving and transmitting system whereby the waves of condensation and rarefaction are concentrated upon one end of a column of liquid in the inner ear. Poised between two elastic membranes, this column vibrates with each air wave provided the frequency of the latter falls within certain limits (20 to 20,000 per second). Exposed to this liquid within the inner ear, specialized cells translate the movements of lymph into nerve impulses, and the auditory nerve carries these to brain-stem centers where they form reflex connections and are also relayed to the higher centers.

This account may be elaborated. The collecting and transmitting system consists of (1) the pinna, or external ear, (2) the external auditory meatus, an open tube 3 cm. long, bending down, forward, and inward, leading to (3) the tympanum, or eardrum, on the inside of which is attached the first of the three bones of the middle ear. The conical gray tympanum, 1 cm. in diameter, is spread like a drumskin, closing the descending meatus, and vibrates in response to the pressure changes set up by a sounding body. Attached to its inner surface is one arm of the malleus, or hammer, the first of the three bones of the middle ear. Bound rigidly together, these three bones form a bent lever, suspended from the roof of the middle ear chamber. Each inward thrust of the drum is thus communicated to the oval window, a membrane behind which lies the column of lymph. Thus the air wave against the tympanum is concentrated upon the smaller oval window, and the leverage provided by the greater length of the outer member of the bone lever (9.5 mm. as against 6.3 mm.—length of the shorter lever) further facilitates this translation from the lighter to the denser medium.[1]

The Inner Ear (Cochlea).—The column of liquid lying back of the oval window extends for 40 mm. in the form of a coiled spiral channeled in solid bone. It is divided into two main compartments by a bony shelf with membranous extension (basilar membrane), the upper compartment (*scala vestibuli*) lying back of the stirrup (stapes), the third bone of the middle ear. The basilar membrane fails to divide the cochlea completely, and the two compartments are joined at the tip (helicotrema), so that the pulse started by the movement

[1] In this translation the amplitude of movement is reduced to circa 0.04 mm., and the intensity of the thrust is increased 30 fold.

of the stirrup travels as a wave up the spiral on one side of the membrane and returns via the lower compartment (*scala tympani*) to impinge upon the elastic "round window" (*fenestra rotunda*) lying just beneath the stirrup and oval window (*fenestra ovalis*). The two

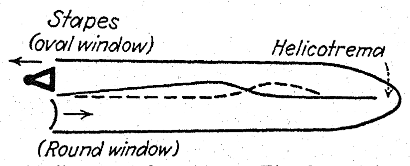

FIG. 32.—Schematic diagram of cochlea. The figure shows the relationships between the parts of the inner ear which would hold if the cochlear tube were stretched out. The basilar membrane (solid line in central portion of figure) all but divides the tube save at the helicotrema. The figure also shows how each movement of the stapes and oval window is compensated for by the action of the round window. It also indicates the manner in which an outward movement of the stapes would displace the basilar membrane and set up a wave which would travel throughout its length. (*After Békésy. From S. Smith Stevens and Hallowell Davis. Hearing, p.* 279, *New York: Wiley,* 1938. *By permission of the publishers.*)

windows thus provide compensating membranes permitting free vibration of the lymph (see Fig. 32).

Mounted upon the basilar membrane are the arched organs of Corti (see Fig. 33) and their specialized hair cells, the latter arranged

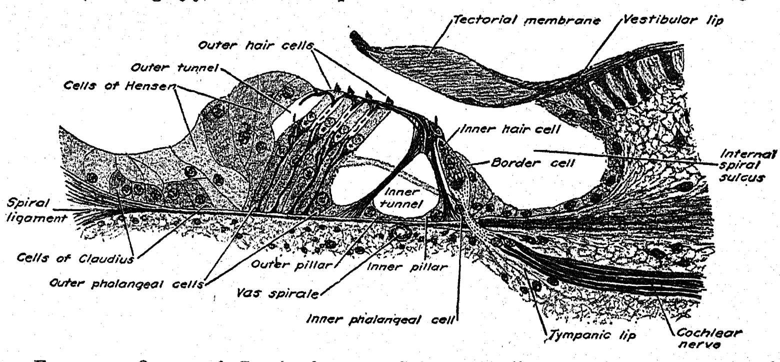

FIG. 33.—Organ of Corti of man. Schematic diagram showing details of structures which are thrown into vibration along with the basilar membrane. When a sound wave displaces the membrane upward the hair cells receive pressure stimulation from the tectorial membrane. This excitation is then transmitted centralward along the auditory nerve leading off to the right. (*From Bailey. Text-book of histology, p.* 738. *Baltimore: Wood,* 1936. *By permission of the publishers.*)

in two rows, an inner row of some 3,500 cells and an outer one of some 12,000 cells. The auditory nerve which rises in the center of the coiled spiral is composed of some 13,000–15,000 fibers which

distribute themselves along the basilar structures from oval window to helicotrema, each fiber reaching one or two of the hair cells of the arches of Corti.

The loaded fibers of the basilar membrane vary in length (0.12 mm. near the oval window, and 0.3 mm. at the helicotrema). They are also unequally loaded and vary in tension, the longer and heavier fibers loosely mounted at the tip, the finer, shorter fibers at the base under considerable tension. These structures may thus be conceived of as a set of string resonators, each capable of responding to a narrow range of frequencies. Like the strings of a musical instrument thrown into sympathetic vibrations by one's voice, these basilar membrane structures analyze a complex of air pressures into the component frequencies and initiate a corresponding pattern of nerve impulses in the auditory fibers.

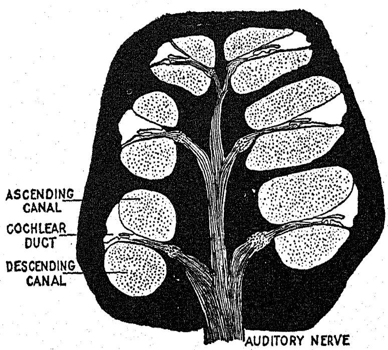

FIG. 34.—Cross section of cochlea. The bony wall of the cochlea is shown in solid black. Arising in the center of the structure is the auditory nerve with its fibers turning off toward the basilar membrane and supported structures. (*From H. C. Warren and Leonard Carmichael. Elements of human psychology, p.* 108. *Boston: Houghton Mifflin,* 1930. *By permission of the publishers.*)

The Results of Cochlear Damage.—While direct observation has not, as yet, verified the details of this description, many lines of evidence support it. When, for example, a limited section of the cochlea of the guinea pig is destroyed, subsequent tests show that there is a localized loss of auditory sensitivity. Certain frequencies are affected, depending upon the location of the injury.

Analogous to this experimental evidence is the observation that boilermakers frequently lose their sensitivity to the higher pitches. A recent study shows that 80 per cent of those with twenty years of service show an inner ear deafness. Where it has been possible to study the cochlea of such patients, extensive degeneration of the lower portion of the cochlea has been found.

While this evidence for a differential sensitivity of the different portions of the basilar membrane seems conclusive, other evidence indicates that, at least with the more intense stimuli, a fairly wide band of fibers is thrown into motion.

The Resonance Theory vs. the "Telephone Theory" of Hearing.— The resonance theory of hearing which has been outlined has met with a great deal of criticism since it was first proposed by Helmholtz. Many scientists preferred to think of the membrane as vibrating as a whole, much as a telephone microphone. The discrimination between high and low frequencies would thus rest upon the rates of excitation of the auditory fibers rather than upon the locus of the impulses within the auditory tracts. Although immediate objection against the theory was raised by those who had found the upper limit of nerve conduction rates to lie at about 1,000 impulses per second, whereas tones as high as 15,000 to 20,000 could be heard, a modification of the theory met the objection. Assuming a frequency of 10,000, one could conceive of its being carried in ten fibers, provided the first ten pulses are carried by ten different fibers in succession. Thus a rotation of fibers might yield auditory nerve volleys up to the desired limits. This question was brought to the foreground of discussion by an observation of Wever and Bray,[1] who found that the auditory nerve of the cat carried electrical effects whose frequency and intensity characteristics corresponded to the curve of auditory sensitivity of the animal. In fact, a microphone attached to the amplified electrical effects reproduced words spoken into the ear of the anesthetized animals. This demonstrated the presence of the disputed electrical frequencies. Later investigations seem to show, however, that these electrical effects are not true action currents of nerve. Although they originate in the cochlea, they persist although the auditory nerve is frozen or partially crushed, and they may be picked up from almost any part of the animal's head if amplification is great enough.

When the true action currents of the auditory nerve are recorded it is found that the fibers carry impulses which reproduce the stimulating frequencies up to 1,000 per second, and to a limited extent even between 2,000 and 3,000. Above this frequency the nerve impulses appear disordered and asynchronous; and it has been found that the synchrony in the lower frequencies declines when the impulse has passed through synaptic connections (as it is relayed centralward). These facts indicate that the final action of the auditory centers in inciting discriminatory responses will have to

[1] Wever, E. G., and Bray, C. W. The nature of acoustic responses: the relation between sound frequency and frequency of impulses in the auditory nerve. *J. exp. Psychol.*, 1930, 13, 373–387.

depend more upon the point of origin in the cochlea and the number of neural elements responding than upon the frequencies carried. Physiologically, pitch discrimination is thus comparable to the tactual discrimination of two points touched upon the skin, the cochlear analyzer placing the peaks of stimulation upon different basilar membrane points. The experimental measurement of pitch sensitivity indicates that under favorable conditions there are about 1,300 discriminable tones within the audible range. If we project this discrimination scale upon the basilar membrane, each "pitch patch" is found to occupy 0.025 mm. Interestingly enough, this is equivalent to the distance occupied by two internal hair cells.

The physical efficiency of this sensory analyzer sets the limits within which auditory cues can operate. Within the middle range of frequencies (500 to 5,000) it proves to be most sensitive, a change of 3/10 of 1 per cent of the frequency being perceptible. The same general area has the lowest absolute threshold, and is also more responsive to intensity changes.[1]

The Human Voice as an Auditory Stimulus.—When we place the human voice against this scale it appears at first glance that the understanding of speech depends upon a very limited portion of this sensitive range, for the human voice covers but three octaves (from 87 to 768 cycles) if we consider merely the fundamental pitch. However, the tone produced by the human voice is a mixed one, the vibrating cords and the resonant air passages adding partials of higher frequencies.[2] It is the particular pattern of these partials that gives each voice its characteristic quality (timbre) and provides the physical cues by which we identify the speech movements of

[1] In the band of frequencies where sensitivity is greatest, from 2,000 to 4,000 cycles per second, 0.001 dyne per square centimeter, will evoke a response, but at the extremes (20 and 20,000 cycles) a pressure change 3,000 times as great is required. At the upper levels of intensity the auditory stimulus introduces tactual and pain qualities.

[2] A vibrating string vibrates not only as a unit, but in halves, thirds, quarters, etc., these smaller segments at higher rates. Thus a string tuned to a frequency of 100 cycles will give off a "fundamental" of 100, and "overtones" of 200, 300, 400, etc. The particular quality, or timbre, of different instruments sounding the same fundamental note is due to the particular pattern of these overtones. It is also true that the shape of the chamber through which the vibration is passed will alter the quality. If the mouth is placed in the positions for the vowels *ah, oo, ee,* the difference appears in whispered sounds (when the vocalized fundamental is absent). Also, percussing the cheek when the vowel position has been taken will reveal the resonant quality of the particular position.

another. Thus, although most of the energy of spoken sounds lies within the band of frequencies below 1,500 cycles per second (and all the "fundamentals" lie here), the sound engineer has found that eliminating frequencies above this level reduces comprehensibility by 35 per cent (although 90 per cent of the energy is still present).[1]

In addition to these partials and formants there are, of course, the changing pitches of the fundamental, which are produced by varying tensions in the vocal cords. Where there is an operation for cancer of the throat and the passageway from mouth to lungs is closed off, a direct opening to the lungs is made through the throat wall. Into this opening the patient inserts the tube of an artificial larynx, consisting simply of a vibrating reed of fixed pitch so arranged that the chest pulse sets it in operation. If the section of tube beyond the reed is placed in the mouth, the normal articulatory movements of tongue, lips, jaw, will produce perfectly comprehensible speech, although it is totally devoid of inflection. But, although such speech is comprehensible and the syllable strokes are properly phrased, we sorely miss the inflections which indicate that a question is being asked, that a sentence is coming to a close, etc. Instead of these modulations which give speech its musical quality, the speech of the person with an artificial larynx is (literally) monotonous; the irritating character of the sustained declamatory tone vividly demonstrates how much we depend upon the modulations of the fundamental tone.

Sensing vs. the Perception of Meaning.—Sound waves vary in intensity (amplitude), pitch (frequency), and timbre (wave form), and in the temporal patterns into which they are organized. The complexities of the external stimulus are matched by the patterns which appear in the cochlear resonator and, in turn, in the auditory-cortical areas, within the limits imposed by the physical characteristics of the resonators and nerves. Although these highly specific (and complex) patterns flood the nervous centers of the child as they do in the adult, before experience has joined them to particular groupings of effectors they cannot be said to have any great amount of meaning. To be sure, the sudden intense pattern of sound may produce the start of fear in the infant, but the sheer intensity of the stimulus, spreading by brute force through the conduction paths,

[1] The sounds *f*, *s*, *z*, *th*, particularly depend upon the higher frequencies (above 5,000).

seems all that is necessary. And the response tends to be diffuse, inchoate. The form of the stimulus pattern has not achieved any importance as yet. So, too, judging from the evidence of Davis and others, the cochlea of the guinea pig behaves with approximately the same efficiency as its human counterpart; but here again, the limited neuromuscular equipment of the rodent sets a limit to what it can perceive. Thus, instead of looking upon the sense organs as "windows of the soul" (as they were once poetically conceived), we might look upon them as the triggers which fire response mechanisms. Judging from the contrast between the behavior of child and adult before the *formal* character of these auditory patterns can serve as a trigger, experience must shape the neuromuscular connections. Or, if not experience, the ripening process of growth. We shall return to the unraveling of these agencies when we take up the question of instinct. In the meantime we shall rest content with the observation that "sensing" the presence of an object involves vastly more than a sense-organ activity or even a sensory-neural action.

The Eye

Of all the senses, vision supplies the most accurate reports of the spatial distribution of external objects. Not only do the visual stimuli warn us of objects-to-come, they warn us of their position, dimensions, and rates of motion. With the eye we see objects-in-relation, and appreciate situations as a whole. When we wish to portray complex relations we resort to visual methods of presentation, graphs, charts, outlines, mathematical and geometrical demonstrations. Our thermometers, calipers, voltmeters, and measuring sticks are all devices for translating the changes so crudely apprehended by other senses into visual terms, pointer readings. Moreover, the thousands of shades and hues warn us of conditions and qualities of distant objects, and—through the neural connections established by experience—mobilize appropriate patterns of movement.

Borne in the head, these sensitive receptors do much to justify the concept of head dominance. The delicacy (low threshold) of the receptor surfaces and their mobile mounting make them admirably adapted for their pace-setting function. But like every other part of an integrated organism, the eye is subject to the whole. The eye of the hungry animal roves in search of food and, triggerlike, releases

the response of approach and eating when the objective is sighted. The eye of the frightened animal roves in search of the avenue of escape, and again serves as releasing trigger. If the eye seems so frequently to control behavior, it is because the eye continuously operates under a roving commission with delegated powers.

The Mounting of the Eyes.—As we survey the visual field the eyes move in a series of rapid jerks (with interspersed perchings), swinging together and stopping with each pupil directed toward the object of vision. The movements are the result of the combined action of six pairs of muscles which move the orbs in their socket mounting. A pouch-shaped capsule (capsule of Tenon) surrounds

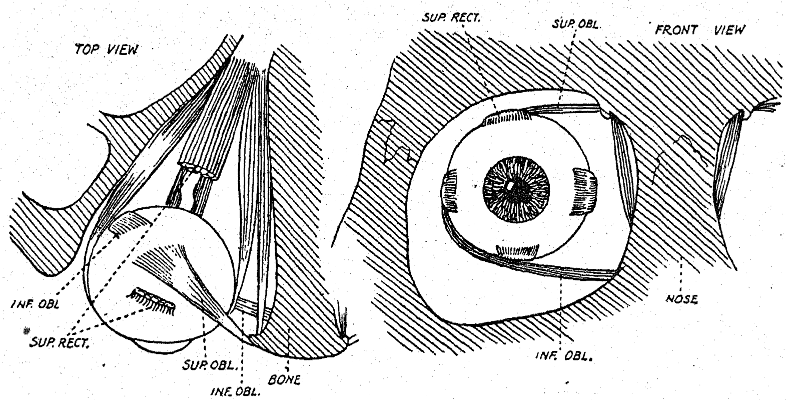

FIG. 35.—Diagram showing eye muscles and their attachment to the eyeball. (*From E. H. Starling. Principles of human physiology, p.* 232. 6th ed. *Rev. by C. Lovatt Evans and H. Hartridge, Philadelphia: Lea,* 1933. *By permission of the publishers.*)

the posterior four-fifths of the ball and contains a lubricating (synovial) fluid. Smooth-muscle fibers in the pouch wall, innervated by the autonomic nervous system, serve to balance the pull of the orienting muscles and to prevent them from pulling the eyeball back in the socket as they contract. The arrangement of the muscles (shown in Fig. 35) is such that, operating singly and in combination, all the eye movements and fixations are possible. Not only is there reciprocal innervation of opposed muscles (*e.g.*, internal and external recti), but appropriate groups in the two eyes operate in unison to keep the two pupils directed at the same point in the visual field. If the eyes move to a new fixation point that is farther from the eye, convergence is altered as the eyes swing and there is an appropriate lens accommodation. Thus, in a single change in

fixation there may be (1) cooperative action of the 12 muscles against a supporting background contraction in the smooth-muscle fibers of the capsule, (2) adjustment of pupil and lens, and (3) possible changes in the lid muscles and the supporting neck muscles, etc. Like the other receptor surfaces, the retina is embedded in the musculature, and while one is constantly tempted to employ the camera analogy in describing the eye, the latter proves to be more lively and adjustable than any of the mechanisms man has yet devised.

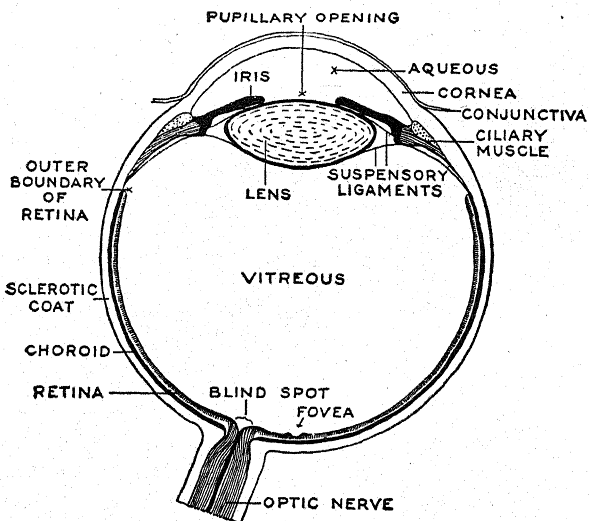

FIG. 36.—Diagrammatic cross section of right human eye. (*From H. C. Warren and Leonard Carmichael. Elements of human psychology, p. 80. Boston: Houghton Mifflin, 1930. By permission of the publishers.*)

Since coordinated movements of the eyes are found in the congenitally blind, they should be thought of as brain-stem reflexes and, although these are educable and capable of readjusting to such conditions as are imposed by the lenses of our glasses, they do not seem to need much tuition in the first place. There is, to be sure, a period when the eyes of the neonate behave in alarming independence, but sheer growth and maturation of the structures comprising these reflex arcs (and not training) seems to be responsible for their development. Electrical stimuli to the frontal cortex, action of the semicircular canals, a point of light moving in front of the open eye, may each initiate these coordinate patterns. The visual object which catches our attention thus automatically pulls

the two eye cameras into position and adjusts their shutters and lenses.

The Gross Structure of the Eye.—The spherical eyeball (20 to 24 mm. in diameter) is formed of three coats distended by the internal pressure of its semifluid contents. The outer coat, or sclera, is a tough, white, leathery membrane, modified in front to form the clear, transparent cornea. The latter, with a greater curvature than the rest of the eye, bulges slightly. Attached at the back of the eyeball and perforating the sclera is the optic nerve, containing axons which transmit the visual impulses brainward.

Inside the sclera the choroid coat, vascular, pigmented, forms a darker lining for the eye camera. Near the edge of the cornea the choroid is interrupted by the ciliary body, which contains the muscle whose function it is to bring about accommodation of the lens. Lying in front of the ciliary body is the pigmented[1] iris, the shutter of the camera, in the center of which lies the pupillary opening. The third and innermost coat, the retina, extends over 207 degrees of the inner surface, and contains the true receptor cells, the light-sensitive rods and cones, together with relaying neurons, blood vessels, and pigmented cells.

The Action of the Iris.—The size of the pupil varies from 2 to 8 mm., depending upon the intensity of illumination and a variety of other factors. This iris adjustment is brought about by two thin sheets of smooth muscle within the tissues of the "shutter": the anterior fibers form a circular sphincter whose contraction "stops down" the pupil, the posterior fibers form radii whose contraction opposes this sphincter action. Autonomic fibers regulate the action of these muscles, a branch of the sympathetic producing dilation, a branch of the cranial division producing constriction. Their opposed action calls for the same mechanism of reciprocal innervation which we have observed elsewhere, and experiment shows that this is indeed the case. Thus, in an experimental animal in which the sympathetic innervation is cut, stimulation of the sensorimotor cortex produces dilation.[2]

[1] The pigment of the iris gives to eyes their characteristic color. It is often deposited after birth, the slate-blue eyes of the neonate being symptomatic of a shortage of pigment in the anterior portion of the iris, a dark pigment at the back showing through. The pinkish eye of the albino is produced by a total absence of pigment, the blood vessels furnishing the sole coloring.

[2] Starling, *op. cit.*, 5th ed. P. 394.

When the eye is suddenly stimulated by a bright light, constriction begins promptly and is observed in both eyes, even when but one has been stimulated. Such constriction gives clearer retinal images, protects the sensitive retinal cells, and confines the light rays to the more efficient central zone of the lens.

Dilation is a slower process and may be initiated by the removal of the light source, a sound (or other moderately intense sensory stimulus), emotional states or drugs (*e.g.* atropine, belladonna,

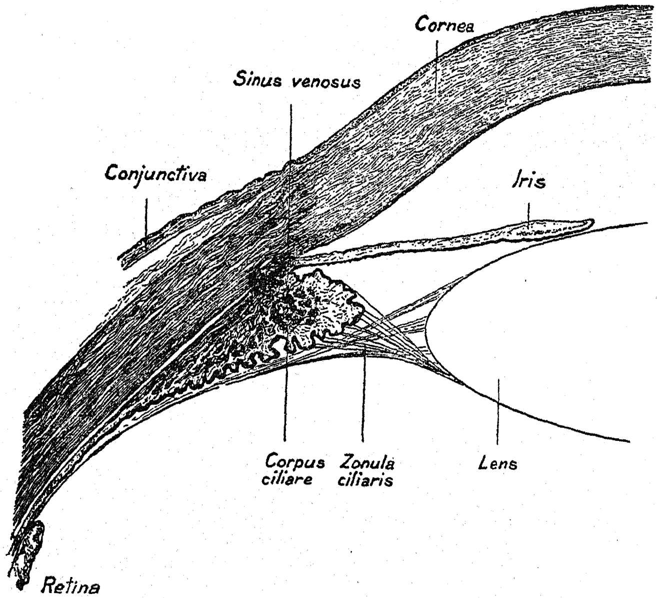

FIG. 37.—Diagram through anterior part of eyeball to show mode of suspension of lens. (*From Starling, op. cit. p.* 404. *By permission of the publishers.*)

cocaine). Where it is initiated by a sudden auditory stimulus (ringing bell) it may occur within a second. The light reflex (constriction) falls below 200 millisec.

In lowered illumination this dilation permits more light to enter the eye, thus facilitating the action of intensities which might otherwise produce subliminal effects. Because of its widespread central connections and its responsiveness to changing organic states, the condition of the pupil provides the clinician with an important diagnostic sign.[1]

[1] The Argyll Robertson pupil, which is unresponsive to light, is one of the diagnostic clues to syphilis of the central nervous system. Although in this case

The Adjustment of the Lens.—The central chamber of the eye is divided into two compartments, the lens forming the partition. The aqueous humor which fills the anterior chamber is a watery liquid formed by the ciliary body, and the rate of its formation and removal determines the intraocular pressure (23 to 40 mm. mercury). The vitreous humor which fills the posterior chamber is a semisolid, jellylike substance which—like the aqueous humor and lens—permits free passage of light to the sensitive retinal structures.

The lens is an elastic biconvex body, whose transparent capsule and contents all have the same refractive index, and it is attached by suspensory ligaments to the ciliary muscle. When the fibers of this muscle (both radial and longitudinal) contract, they pull the choroid coat forward and form a smaller circle, thus relaxing the tension upon the ligaments which support the lens; and under these conditions the elasticity of the latter causes it to bulge, increasing the surface curvature. Thus, when the ciliary muscle contracts, near objects are brought into focus. Conversely, as the ciliary muscle relaxes, the internal pressure of the eyeball pushes back the choroid, and the lens is thus pulled back into the flatter shape. The elasticity of the lens commonly declines with age, and at 45 to 50 years the average eye requires the assistance of convex glasses for near vision. These lens adjustments are quite automatic, and the brain-stem centers supplying the ciliary muscles of the two eyes are so integrated that (as with the pupil) accommodation of one eye is regularly accompanied by a similar adjustment of the other.

The Structure of the Retina.—Figure 38 shows the detailed structure of the retina in schematic form. The outermost pigmented layer, lying next to the choroid coat, is composed of a single layer of hexagonal cells. A twofold function is ascribed to these cells: they surround the sensitive rods and cones, thus preventing reflection and diffusion of entering light, and they also protect these sensitive endings from excessive stimulation.

Passing inward (*i.e.*, toward the center of the eye), we find the layer of rods and cones, the photoreceptors proper. The shapes

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the pupil does not react to light, it may still contract as the lens accommodates for near objects. Normally constriction of the pupil accompanies fixation of near objects. Since the sympathetic division of the autonomic innervates the dilation fibers, the enlarged pupil will characterize states of fatigue, and emotional excitement.

of these structures vary considerably in different retinal areas, as Fig. 39 indicates. In general, the rods may be distinguished by their long, rod-shaped tips, in contrast to the conical tips of the stubby cones; but at the fovea (a central area where sensitivity is greatest)[1] the cones are so crowded and elongated that they closely

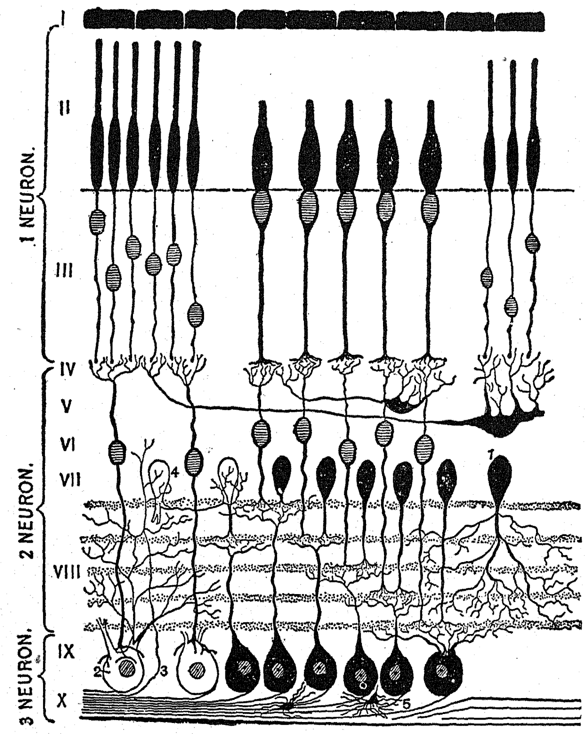

FIG. 38.—Schematic representation of structures in the retina. The layer of pigment cells shown at the top of the figure (I) lies next to the choroid coat. Proceeding toward the front of the eye, there are represented the rods and cones (II), the bipolar cells (VI), the large ganglion cells (IX), and their axons, which unite to make up the optic nerve (X). (*From W. H. Howell. A textbook of physiology, p.* 371. *Philadelphia: Saunders*, 1934. *By permission of the publishers.*)

resemble the rods in form. At the fovea there are no rods. Immediately surrounding the fovea rods appear, and as one passes toward

[1] Fixation of the eye upon a point of light always turns the orb so that object, pupil, and fovea are in line, thus throwing the image upon the most sensitive retinal area.

the periphery the cones grow fewer in number until at the periphery rods predominate. The rod-free fovea covers about 0.8 mm., and within this area the cones are so tightly packed that, seen in transverse section, the thicker portions appear hexagonal. One estimate places their density at 120,000 to the square millimeter.[1] As we shall see later, there is conclusive evidence that the rods are involved in the perception of twilight grays, the cones in daylight brightnesses and color.

The changes set up in these sensitive endings travel over rod and cone axons to a second bipolar relaying cell, and this in turn connects with the large ganglion cells which give rise to the fibers which constitute the optic nerve.[2] All the latter leave the eye at one point, the blind spot,[3] an area about 1.5

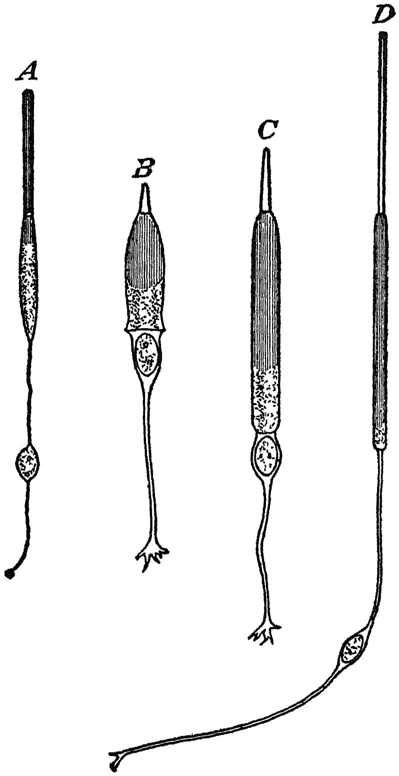

FIG. 39.—Retinal rod and cone cells. Diagrammatic representation of short stubby cone cell (*B*) and slender rod cell (*A*). Transitional forms of cone cells are shown at (*C*) and (*D*). (*From L. T. Troland. Principles of psychophysiology. II, p. 103. New York: Van Nostrand, 1930. By permission of the publishers.*)

[1] Creed, R. S., and Ruch, T. C. Regional variations in sensitivity to flicker. *J. Physiol.*, 1932, 74, 407–423. The dimensions of the rods are given as 2 to 4 μ (diameter) and 40–60 μ (length); the cones 4 to 6 μ by 30–40 μ The cones approach the rod dimensions at the fovea (μ = 0.001 mm).

[2] Each optic nerve contains about 500,000 fibers. Starling, *op. cit.*, p. 405.

[3] The blind spot is about 18 degrees on the nasal side of the fovea. To demonstrate the existence of this insensitive area, close the left eye and fixate the right on two spots separated by 2½ inches. If the fixation surface is moved toward and away from the eye, a position will be found (*ca.* 10 in.) at which the right-hand spot disappears. The fact that this insensitive area does not appear as a "hole" in the visual field raises an interesting question for students of visual perception.

mm. in width, from which all rods and cones are crowded aside by the departing fibers.

In the region of the bipolar cells there are cells of a different type which make transverse connections between rods and cones. Their arrangement suggests an integrating function, and it is possible that they figure in contrast effects, but as yet these inferences lack experimental proof.

The Fovea.—The arrangement of retinal structures which are here described seems awkward from one standpoint. The light which enters the eye passes through cornea, aqueous humor, pupil, lens, vitreous humor, and then must filter through eight layers of the retina, with their ganglion, bipolar, horizontal, and supporting cells, and blood vessels, before striking the sensitive rod and cone endings. At the fovea most of these intervening structures are absent, and the light has more direct access to the receptor cells. There are no intervening blood vessels here. These facts, together with the density of the endings, make the fovea the area of clearest vision. It is also true that in this region there is a 1–1 ratio between cones and bipolar cells, a relation not preserved at the periphery, where there are fewer endings and where one relaying cell may serve two or more receiving cells.

The musculature which adjusts the eyes to the object of our attention (six pairs of eye muscles, iris, ciliary muscles) throws a sharply defined image upon this foveal area. Even the eyes of the neonate show these reflex adjustments, though in imperfect form.

The Stimuli for Vision.—High-speed electromagnetic waves, traveling at 186,000 miles per second and varying in length between 400 and 760 $\mu\mu$, provide the adequate stimulus for vision. Beyond the visible spectrum, the longer (infrared) waves are felt as heat, the shorter (ultraviolet) waves—while not directly sensed—initiate chemical changes in our tissues which are quite perceptible (*e.g.*, sunburn). Thus, of the known forms of radiant energy, from the long Hertzian waves employed in radio broadcasting (5 to 15,000 m.) to the cosmic rays (0.001 $\mu\mu$) relatively few are visible, *i.e.*, excite the rods and cones of the retina. Unquestionably the fact that the energy of the sun's rays reaches its maximum within the 400 to 760 $\mu\mu$ range has figured in the evolution of our particular form of sensitivity.

The visible rays, which now concern us, may vary in wave length, intensity, and homogeneity (or purity). If we could excite the fovea

with a pure source of sharply defined wave length, and allow it to vary from 760 to 400 $\mu\mu$, we would perceive, in succession, red (760 to 650 $\mu\mu$), orange (650 to 600 $\mu\mu$), yellow (600 to 550 $\mu\mu$), green (550 to 500 $\mu\mu$), blue-green (500 to 450 $\mu\mu$), and violet (450 to 400 $\mu\mu$). A mixture of all wave lengths would produce white light. Conversely, a prism will split white light into its component waves (the index of refraction is greatest for violet, least for the red component). The spectrum produced by this splitting of white light contains an infinite number of wave lengths which, when viewed by the eye, produce a series of such gradual color transitions that no sharply defined boundaries can be marked. Therefore, the most obvious answer (on both physical and psychological grounds) to the question, How many colors are there? is to say that the number is infinite. But, like the conventional scale of music, our color vocabulary marks out certain zones. Again, as with tone, we may "pace off" the visible spectrum into just-noticeable steps, in which case we find that there are some 128 discriminable steps.[1]

Of the visible wave lengths, those at the extremes of the spectrum are least capable of arousing retinal response. Thus, if we could experimentally equate the energies in each portion of the spectrum and then simultaneously lower all the intensities, the reds and violets would disappear first, the yellow last of all. Thus, both the wave length of the source and its intensity will alter the magnitude of the physiological response.

Purkinje Effect: Rods and Cones.—As the physical intensity of the spectrum is lowered, two important changes occur: (1) the colors, disappear and are replaced by a band of grays, varying only in brightness and (2) the point of greatest brightness shifts toward the position occupied by green in the daylight spectrum (from 554 $\mu\mu$ in the daylight to 511 $\mu\mu$ at twilight values). This is explained by the fact that the weaker intensities stimulate the rods only. These latter structures not only are more sensitive than the cones, but are more responsive to the shorter wave lengths. Thus, a red that is more brilliant than a blue at daylight intensities will appear duller at twilight values (in the latter case colors have disappeared altogether, and grays are being compared). This *Purkinje effect*—as it is called—will be absent from the fovea, since the latter possesses cones only.

[1] Jones, L. A. The fundamental scale of pure hue and retinal sensibility to hue differences. *J. opt. Soc. Amer.*, 1917, 1, 63–77.

Adaptation.—As we move from a brightly lighted room into a darkened one we are at first unable to make out any objects, but as time passes their outlines begin to form. Visual sensitivity increases, rapidly at first and then with decreasing speed: most of the increase is accomplished within 20 to 30 min., although some changes continue throughout 24 hr. When fully dark-adapted, the rods will respond to stimuli of 1/10,000 the original threshold value. At the fovea (where rods are absent) the increase in sensitivity is also noted, although not nearly so marked (1/100 original threshold). These facts explain why under low illumination we can sometimes see better when looking just to one side of the object. Although under moderate intensities the fovea gives the sharper outlines, at twilight values the rod-free fovea is less sensitive than the neighboring rod-covered surfaces.

Dark adaptation is due to the resynthesis of compounds broken down by the action of light. One of these compounds (visual purple) has been described. It is reddish in color and is found only in conjunction with the rods. If a frog is kept in the dark for some time before killing, and the eye is removed under red light (as in photographic work), the retina appears dark red on first exposure to daylight; but it rapidly bleaches to a colorless gray. Experimental studies have shown that the bleaching effects of different wave lengths upon extractions of this substance correspond with the effectiveness of these same frequencies for human vision at low intensities. If we were to plot two curves, one for the sensitivity of the retina to the various wave lengths at low illumination and one for the absorption spectrum of visual purple, the two curves would be found to be practically identical.

No corresponding photosensitive substance has been identified for the cones, but the probability is that such substances are responsible for the color responses of the cones.

The resynthesis of these photosensitive compounds when light is withdrawn renders the eye more sensitive, since their greater concentration increases the amount of chemical change produced by a given light. Light adaptation, on the other hand, is marked by decreasing sensitivity because of the partial depletion of these substances. The process of resynthesis takes place at a slower rate than the breakdown (until an equilibrium is reached). The rapidity with which the daylight glare (which we experience on emerging from a darkened room) passes shows the speed of this light-adapta-

tion process. The equilibrium point is reached for foveal stimulation in about 90 sec.

Growth and Decay of the Visual Response.—A light flashed on and off in a darkened room produces a visual response which will last beyond the duration of the stimulus. In fact, with a very brief stimulus the whole visibility period may lie outside the stimulation period. Before rods and cones respond, a chemical change of a certain magnitude must take place, and this process requires a measurable amount of time. So, too, chemical changes induced by radiant energy continue to excite nerve impulses after the external

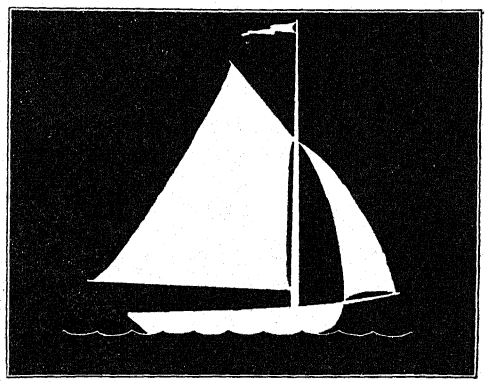

FIG. 40.—Afterimage figure. Fixate a point in the figure for from 20 to 30 seconds, and then look at a neutral gray surface. The negative afterimage, with brightness values reversed will gradually appear. *(From S. W. Fernberger. Elementary general psychology, p. 63. Baltimore: Williams & Wilkins,* 1936. *By permission of the publishers.)*

change has ceased. This persisting *positive afterimage* is of the same quality as the initial response. With sufficient exposure, other pronounced aftereffects are experienced, the most noticeable of which is the *negative afterimage*, of an opposite or complementary color. If one fixates a black-white figure, such as Fig. 40, for a half minute or more, and then turns to a neutral surface, the "negative" will appear with the black-white relations reversed. A plausible explanation in chemical terms, involving the principles invoked to explain adaptation, has been proposed. During the fixation period the retina is unequally illuminated, the brighter portions of the stimulus pattern producing greater local exhaustion of the photosensitive substances. When the eye is then turned to a neutral surface, although energy is uniformly reflected to the retina, the

depleted areas are unable to give as full a response as those previously exposed to the black portions. Hence the reversal in values. A similar explanation has been suggested for the case of colors, based on the assumption that there are a few primary photosensitive substances in the cones, that exposure to one wave length exhausts a part of these, and that the remainder then respond to the light reflected from the neutral surface. Since the neutral surface reflects all wave lengths, it contains those which will arouse the unexhausted components. We shall return to this question after we take up the concept of primary colors more fully.

The aftereffect of excitation may be shown by other methods. If a light source is interrupted with gradually increasing frequency, a point will be reached where the flicker disappears[1] and the light appears to be of constant brightness. The retinal responses lag and overlap, so that although the external stimulus is intermittent the retinal excitation is continuous (or better, its rate of change falls beneath the threshold value).

Mixing Wave Lengths.—If a disk composed of sectors of colored papers is mounted upon the shaft of a small motor and rotated at a speed above this fusion point, colors are mixed as effectively as though separate beams of differing wave lengths were thrown upon the same retinal area. Certain facts emerge from such a mixing process:

1. If we select colors of not too divergent wave lengths (*e.g.*, red and yellow), a series of intermediate colors can be produced by varying the proportions of the components. Although the intermediates are produced by two distinct sources, their effect upon the retina is similar to that of a single wave length lying between the two components.
2. Color pairs will be found whose mixture produces a gray. Though the color quality disappears, brightness is not lost in the cancellation process, but lies between that of the components. Examples of complementary colors (as such mixtures are called) are: red (656 $\mu\mu$) and blue-green (492 $\mu\mu$), yellow (569 $\mu\mu$) and blue (460 $\mu\mu$).
3. Mixtures of red and violet produce colors (purples) for which no single corresponding wave length can be found.

These facts have been schematically summarized in the form of a color pyramid (see Fig. 41). Located about the base of the pyramid are all the hues of the visible spectrum together with the "synthetic

[1] This point will vary with intensity (and at lowest intensities, with wave length). For medium intensities 30 to 40 alternations per second are required.

purples." (This latter item should serve to remind us that the pyramid is a representation of the color *response*, or "sensations," and not a description of stimuli.) The line *WB* represents the achromatic series, the grays, ranging from white to black through the intermediate brightnesses. Like the purples, these daylight grays are always produced by a mixture of wave lengths, the position of the gray on the *BW* line varying with the level of retinal response. Above and below the base of the pyramid the surface may be taken to represent mixtures of the saturated hues with a hypothetical "black process" or "white process," yielding the shades and tints of all the colors. The lines lying in the plane of the base of the pyramid, as *BY*, represent mixtures of the saturated hues (on the periphery) with the neutral gray of equal brightness (the point of intersection of *BY* and the plane of the base). Thus a movement from *B* toward this point of intersection reduces the amount of color without changing brightness. Such a change is called a reduction in saturation.

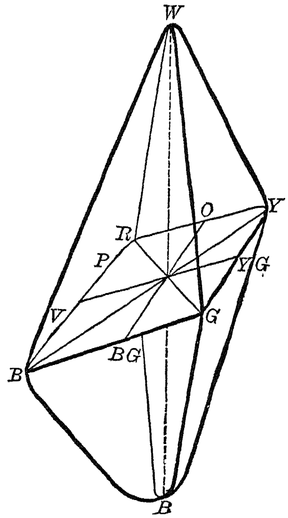

FIG. 41.—Color pyramid. (*From E. Titchener. Textbook of psychology, p.* 63. *New York: Macmillan,* 1928. *By permission of the publishers.*)

The hues are so arranged about the base of the pyramid that any diagonal will have complementary colors at its two ends (*BY*, *RG*, etc.). Thus, we see that there will be an infinite number of color pairs, although if we speak in terms of wave lengths no single complementary wave can be found to balance those lying between *G* and *YG*. However, a mixture of wave lengths can be found which will neutralize these. If the pyramid were changed to a double cone it could be made to represent a fact not included in our summary. As the pairs of hues which are mixed approach the complementary position their saturation falls. The intermediates produced by mixtures of near-by frequencies are of higher saturation. The latter would not lie on the periphery of the base, but on a chord directly connecting their positions. The nearer the complementary position the closer the chord approaches the axis, and when the complementary proportion is used saturation falls to zero.

If one does not inquire too closely into the physical correlates of the figure, and its parts, the double cone (or pyramid) will serve as a shorthand description of the phenomena of color mixing. Since, however, the "laws" of color mixture must ultimately be related to wave lengths, intensities, physicochemical retinal processes, a reformulation is demanded. As we shall see, this reformulation is incomplete.

Are There "Primary" Colors?—Just as there has been a search for separate end organs in the skin, and for "primary" tastes and odors, so color theory has sought to define the nature of the elementary photochemical processes underlying our perceptions of reds, greens, etc. The facts of color mixture indicate that the whole range of hues can be produced by a few (three) wave lengths, if these are properly chosen. Is it not possible, therefore, that very few photosensitive substances will provide (through their combined effects) the whole range of retinal effects?

Helmholtz proposed three primaries, red, blue, and green, selecting this triad because from various combinations of these "primaries" white light and all the hues could be produced by mixture. While other combinations of wave lengths will accomplish the same end, Helmholtz selected three as the smallest number, and that particular group of three which produced mixtures in maximum saturation. All the facts of color mixture can be covered by the Helmholtz theory, but there are other facts to which it is less applicable.

Peripheral Vision.—All colors are seen at the center of the visual field, in an intermediate zone yellow and blue are easily seen, but at the periphery only special modes of stimulation yield a color response. We might expect a decline in color sensitivity on anatomical grounds, for the number of cones falls as we move toward the periphery. The qualitative change in the color responses raises a difficulty for the Helmholtz theory, however—a difficulty which appears insurmountable. When red, blue, and green are selected as primaries, yellow is viewed as due to a mixture of the red and green processes. The facts of peripheral vision show that yellow is perceived where both red and green processes do not function.[1]

[1] A simple demonstration of these zones is easily made. Fixate upon a central point while another person moves a bright-red colored square from the edge of the field toward the fixation point. It will be seen first as a colorless moving object, then as yellow, then as bright red. Repeat with other colors All will be seen in true color within an area of *ca.* 20–30 degrees about the fixation point.

Color Blindness.—Of the many varieties of color blindness which have been described, two types raise questions which are important for color theory: (1) dichromatism, with the subtypes (*a*) protanopia and (*b*) deuteranopia, and (2) monochromatism.

In dichromatism accurate color discriminations can be made within the yellows and blues, but a group of colored yarns containing red, orange, yellow, and green cannot be classified properly, and a green-blue will be matched with a gray. Blue-violet and purple appear as blue. Four per cent of all males, and 0.4 per cent of all females show this form of red-green blindness. The defect is commonly described as heritable, behaving as a sex-linked character. Within the dichromats two types are distinguishable: protanopes, whose sensitivity curves resemble those for rod vision in the normal eye; deuteranopes, whose sensitivity curves resemble those for cone vision in the normal eye. Both see the band of colors which includes red, orange, yellow, and green, as yellow; but for the protanope the red is very dark and the spectrum may be shortened at the red end, whereas the deuteranope's "yellow" seen at the end of the spectrum containing the longer wave lengths (red to the normal eye) is bright (normal daylight values).

The totally color blind are less common (1:40,000). Here cone vision is entirely absent, and the fovea is often totally blind. The brightness values are those of normal twilight vision, and the eyes unusually sensitive to levels of intensity which are easily tolerated by the normal eye. Occasionally individuals are found with cone vision only (hemeralopes). Such persons are "night blind" and show no Purkinje effect.

Again, as with peripheral vision, the three-color theory fails to account for the relationships. Why do red and green disappear together, and why are there not cases of red blindness and green blindness?

Conflicting Theories of Color Vision.—The theories of Hering and Ladd-Franklin offer somewhat better theoretical frameworks, but neither can be said to have advanced much beyond the speculative level. Christine Ladd-Franklin proposed an "evolutionary" view of the color receptors, suggesting that the present primary substances represent cleavage products of some primitive "mother-substance." Thus, this mother-substance, while photosensitive, responds in the same manner to all wave lengths—and would initiate behavior typical of the more primitive photosensitive animals where it is

the intensity, and not the wave length, that matters. From this Ur-substance two products are differentiated, the "yellow substance" and the "blue substance." The former further differentiates into "red substance" and "green substance." Her theory provides, she believed, an account of the peripheral yellows so troublesome to the three-color theory of Helmholtz—the peripheral areas being described as in a more primitive condition, the fovea representing the last stage of the evolutionary process. The red-green blindness, found in 4 per cent of the males, represents an atavism, she believed, the latest evolutionary products being the first to go. She explained the facts of color mixture as due to a resynthesis of the cleavage products: thus, *R*, *G*, and *B* produce white, and *R* and *G* produce yellow. Negative afterimages were explained as "fatigue" phenomena. Thus, fixation upon *B* exhausts this component and the subsequent neutral surface which would ordinarily excite all the primaries now excites merely the remaining unexhausted elements, *R* and *G* (*i.e.*, yellow), the complementary color. As yet, however, the theory lacks both chemical and biological confirmation. While studies upon color sensitivity in animals are limited, those which we have show a distribution of discriminatory powers not in conformity with the evolutionary scheme proposed.

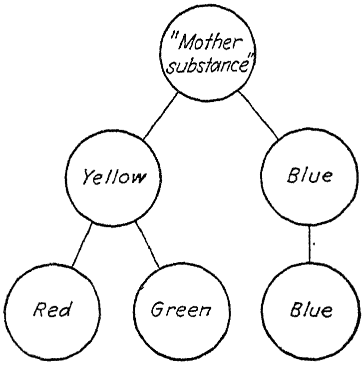

FIG. 42.—Scheme to illustrate the Ladd-Franklin theory of color vision. A "mother substance" is shown dividing to yield two photosensitive substances which are differentially sensitive to long and short wave lengths. The primitive "mother substance" would characterize the eyes of the animal unable to discriminate between wave lengths. The "yellow" substance in turn breaks up into two photosensitive substances which are in turn differentially sensitive to the red and green portions of the spectrum. Color mixture is viewed as a process in which the compounds are resynthesized; and the different color zones of the fully developed human eye may be viewed as analogous to different stages in the evolutionary process.

Hering also chose four primaries, red, green, blue, and yellow;[1] but, though the color names are identical with Ladd-Franklin's, the wave length of the sources differ. This is apparent as soon as

[1] In addition he proposed a black-white pair giving rise to an independent achromatic series.

we examine the Hering "facts." Mixtures of red and green give gray (not yellow). This cancellation of color Hering attributes to the opposed character of the two chemical reactions. If we think of the red-green pair as one organ, and the two opposed processes as anabolism and catabolism, the joint action of the two wave lengths will leave the two opposed effects balanced. Similarly he looked upon the yellow-blue and black-white processes as opposed pairs of processes joined in one organ. Under this view the negative afterimage is given a pseudochemical explanation, the complementary color being induced in the return to equilibrium. Thus, in a state of rest the two processes are balanced, the long wave length drives the reaction in one direction upsetting the chemical equilibrium, and removal of the stimulus leaves an excess of one product. The return to equilibrium represents, therefore, the same type of cone action which the complementary wave length would induce. Contrast effects, induced by surrounding a color by its complement, are similarly explained. The products produced by excitation in one area spread to neighboring cones; but since these are not activated by the same light source such products would be present in excess amounts, and the reaction proceeds in the reverse direction toward equilibrium. Thus, gray in a field of blue takes on a yellowish tinge, in a field of red a greenish one. The complementary colors are thus viewed as tied together as the two sides of a reversible chemical equation.

These color theories have served an important function as guides to research, but they are in no sense to be confused with a factual description, and none of them is entirely adequate—even as description. They are presented here in this fragmentary fashion as illustrations of scientific thinking-in-process. Both electrophysiology and photochemistry may be expected to yield important contributions to our knowledge of retinal process in the future; but the data currently being collected do not lend themselves to any clear generalization.

CHAPTER IV

THE EFFECTORS

The Neglect of the Effectors

Traditional psychology has had little to say about the effectors. In part this may be attributed to an almost obsessive interest in the problem of knowing, and in part to the animistic tradition which has placed "mind" in the brain. The receptors were studied, for these were viewed as the gateways from the external world to the mind, but here physiological interest stopped. There was almost no concern with the effectors, for these were viewed as mere servants of the "idea." According to the older conception, impressions received by the sense organs and transmitted to the brain were here elaborated ("in consciousness") to become ideas, concepts, and plans of action. If interest turned to action itself, the descriptions were seldom in terms of muscular contractions, but rather on an entirely different level. Breathing, running, fighting, speaking, writing, singing, and bricklaying are activities which involve the muscles, to be sure; but even if we were to photograph these we would know comparatively little about what the effectors are doing.

As a matter of fact, almost all psychological analysis is carried on at this level of description. The *stimulus* is commonly described in "meaningful" terms (as, *e.g.*, "food") and not in the language of physics.[1] Likewise, the response is described in molar (as contrasted with molecular) terms as, for example, when the food is said to arouse hunger, desire, eating. Some psychologists have made a fetish of this language of "wholes," arguing that "the whole is greater than the sum of its parts," or at any rate that it has properties that cannot be deduced from the parts. The Gestalt school of psychology, in

[1] The term "meaningful" is perhaps unfortunate, but it may serve to describe the common-sense type of descriptive term from the language of physics and chemistry which speaks of centimeters, grams, seconds, etc. Whereas for common-sense "red" may suffice, scientific description will want to know wave length. intensity, etc.

particular, argues that it is precisely in such wholes that the psychological problem is to be found.[1]

In any case, whether through preoccupation with the problem of how we can know (perceive) the outer world, or from an animistic approach to all psychological problems, or from having made a fetish of the language of wholes, the fact is clear: the effectors are both taken for granted and neglected by psychologists. It is as though the psychologist had decided that the effectors are mere agents, that their duties consist in carrying out what other tissues had planned, and that they merely make possible behavior. In short, psychology has either isolated the "individual" in which it is interested, setting up the individual as something over and against the musculature, or, where the behavior of the whole organism is described, the vocabulary is one of "activities," something quite different from muscular contractions.

A genuine "motor psychology" which describes in accurate fashion the action of the effectors in the common skills (speaking, writing, reading, typing, piano playing, etc.) has yet to be written, and before this can be done much research will have to be undertaken. We can scarcely pretend to have a complete "psychology" of language when we can barely describe the movements involved in producing the syllable, nor a complete "psychology" of artistic creation when we do not know how the muscles operate in drawing a simple circle. And because of the serious gaps in our knowledge, the teaching of all our basic skills is largely a hit-and-miss affair. We are able to set tasks and measure (and correct) end results; but we have been grossly negligent of what happens between.

The behaviorists were the first to call attention to this defect, but their contribution has been mainly a negative one—so far as the present issue is concerned. Watson urged "a clean break with the whole concept of consciousness,"[2] maintaining that he could "find no evidence for 'mental existences' or 'mental processes' of any kind,"[3] and proposing a stimulus-response formulation in the terms of natural science. And Watson's textbook, introducing a treatment of glands and muscles, reminded the profession that they had

[1] Cf. Tolman, E. C. *Purposive behavior in animals and men.* New York: Appleton-Century, 1933.

[2] Watson, J. B. *Psychology from the standpoint of a behaviorist*, Preface, p. viii. Philadelphia: Lippincott, 1924.

[3] *Ibid.*, p. 2.

been describing organisms as though the latter were composed merely of sense organs and nervous system. But, although the effectors were included in his account of the mechanism of response, and although it was proposed to study the action of the "whole organism," Watson's description is carried on in molar terms. Even when he speaks of reflexes, the "functional" terminology (grasping reflex, righting reflex, knee jerk, scratch reflex, swallowing reflex), the objective psychologist is all too often noncommittal as to what goes on within the effector groups.

Mind and Muscle.—Why need a psychologist trouble himself about the musculature? Is it because "mind," as now conceived, has moved out to more spacious quarters, taking up residence *in* the muscles (and glands) while retaining occupancy of its older bailiwick? It would indeed be unfortunate if we merely substituted one animism for another; and while it is probably true that mind is as much *in* the muscles as it is *in* the nervous system, it is equally true that mind is *in* neither. Locating mind is somewhat like locating horsepower in an engine, or sweetness in a lump of sugar. Like the engine's horsepower, which is something developed when all its parts are acting in unison, mind appears in activities, and is not a drop of essence added to inert parts, nor some hidden "genius" lurking in the crannies of the organism.

When we set out to study human behavior (or consciousness) we have no choice but to study *all* the working parts. We cannot divide responses into two great categories, mental and nonmental, nor can we select certain organs and neglect others. If today we neglect the liver and the pancreas, tomorrow we shall have to consider them as we attempt to account for the "bilious" and the "diabetic" personality. And if for most of our psychological concerns we neglect the bones, teeth, hair, nails, it is because they are structures which change so slowly that, like factors appearing on both sides of an equation, they may be dropped. When hair is a carrot-red, or when its departure marks an individual as past middle life, even a "mentalist" must include these factors in describing the social adjustment of the individual.

The case for the musculature is clear. We have already pointed out that the smooth muscles provide a continuous stream of impulses to the central nervous system, and that spasms of contraction in stomach muscles, bladder, etc., may *initiate* and *regulate* activities in other structures. It is equally true that the muscles are involved

in *storing* the effects of stimulation. When a situation has left us tense, anxious, worried, the tonus of our muscles betrays the fact. Indeed, without those circuits (reflex circuit, page 43) which involve the musculature it is difficult to see how any stimulus could produce anything but the most transient effects. The high-speed neural impulse, with its all-or-none character, is over in a matter of milliseconds. It is the *organism* which remembers the insult hours afterward, and in this persistent reverberation, in which one response invokes another, the muscles and glands are intimately involved.

Lest there be any misunderstanding, let us be explicit. This hypothesis is intended to hold for what we term *awareness*. If we could paralyze all the musculature, without interfering with the functioning of sense organs or nerves, we ought thereby to destroy all *consciousness*. To be aware of a stimulus, according to this notion, is to respond to it. By this one does not mean that muscular response and awareness are equivalent terms, but rather that the full arcs, involving effector changes, afford a minimum requirement. We shall return to this question in later discussions of thinking, and perception, where supporting evidence is discussed.

The Effectors and Learning.—A natural extension of the above hypothesis to the case of learning would describe the latter as a reorganization of responses. "We learn by doing" has long served as a slogan for a certain school of educational psychology: our hypothesis generalizes this formula. Without effector action, a situation has no power to reorganize behavior. An experiment by Harlow and Stagner may serve to illustrate the point.[1]

If cats are placed in a basket previously wired so that closure of a circuit will give the animals a shock, and if, before each shock a warning light is flashed, a few such paired presentations will produce a *conditioning* so that the flash alone will send the animal over the side of the basket. Such a process would have been described, at one time, as due to the association of two sensations (visual and pain). Thus, one might argue that the "light sensation" had become associated with the "shock sensation" by the training, so that a later presentation of the light aroused a "mental image" of the other, and in consequence of the latter the animal jumped (in order, of course, to avoid the shock stimulus). An older psychology

[1] Harlow, H. F., and Stagner, R. Effect of complete striate muscle paralysis upon the learning process. *J. exp. Psychol.*, 1933, 16, 183–294.

described such association as in the brain and saw little reason to trouble about the movements, accepting them as "natural" under the circumstances. Harlow and Stagner modified the procedure described above by administering curare to one experimental group before the training procedure. Now, curare (arrow poison) paralyzes the voluntary musculature, leaving smooth muscles unaltered. It does not interfere with either neural or receptor action. Thus, although the cats did not jump, the flash of light produced normal pupillary constriction and the shock was followed by pupillary dilation. When the training was over and the curare effect had subsided, it was found that the curarized animals did not jump in anticipation of the shock. (Though repeatedly stimulated, they had never been made to jump.) On the other hand, they did show a conditioned pupillary dilation. Thus the learning which appeared was limited to those responses which had actually appeared in training. The association which was formed was between the stimuli and the muscular reactions actually made. No response: no habit formed.

There is every reason, therefore, to include the effectors in our survey of the machinery of response. Not only do countless specific acts call for a movement analysis which is today totally lacking, the very processes which are so typically "mental" (*e.g.*, learning) clearly involve these structures.

The Striped Muscles

A muscle is composed of thousands of fibers. In striated muscle the fibers (3 to 5 cm. in length, 0.1 to 0.01 mm. in thickness) are grouped in bundles, and these in turn encased in a connective-tissue sheath. It is the joint action of the minute fibers that produces the contraction of the muscle. The single fiber is striated, or banded, semiliquid in consistency, and contains in turn smaller threadlike fibrils which run the length of the fiber. Alternate dim and light disks make up the fibrils, and it is the falling together of these disks that gives the fiber as a whole its banded appearance. The sarcoplasm which fills the space within the fiber not occupied by the fibrils is regarded as nutritive in function; the fibrils as the true contractile elements. Although the details of fibril action are not fully understood, it is generally agreed that their shortening and bulging is the basic process in all muscular action.

Fiber contractions occur in response to direct mechanical action, to electrical stimuli applied directly to the muscle tissue or to the motor nerve, or by appropriate stimuli acting upon receptors lying on the afferent end of the reflex arc of which the muscle is a part. Although these striated muscles are frequently called "voluntary"[1] (*i.e.*, under the control of the "will"), their action occurs in response to excitation in all cases, commonly to volleys of impulses which descend the motor nerve. The motor nerve which enters the muscle divides and subdivides until each motoneuron reaches, on the average, 100 muscle fibers. In those smaller muscles where precise control is shown, the proportion of nerve fibers to muscle fibers is higher (1:20). Thus, while the single muscle fiber is regarded as the contractile unit, the neural arrangements indicate that these go into action in "gangs."[2] Since the fibers operate on an all-or-none principle, as do the neurons, the gradation in the intensity of a response is seen to be a step-wise affair, as gang after gang of fibers go into action under gradually increasing stimulation.

The Muscle Twitch and Tetanus.—If a single volley of nerve impulses is set up by a break shock applied directly to the motor nerve, and mechanical and electrical records are taken, the latter will show an extremely brief action current and a somewhat longer shortening phase. The continuation of the shortening phase is such that successive break shocks (inducing discrete action-current pulses) produce a fusion in the tension record when the frequency of the separate volleys reaches 70 per second.[3] Such a fused,

[1] Not all "voluntary" muscles are equally accessible to the will. The muscles which move the ears backward (retrahens) are commonly "involuntary" in the sense that they cannot be moved intentionally, although with special training they can be brought under voluntary control. Further, numerous records describe cases in which there is a "voluntary" acceleration of the heart, contraction of the iris sphincter, etc., showing that special training can bring the normally inaccessible type of muscle (smooth muscle, heart) under control.

[2] Eccles and Sherrington report 430 such units in the gastrocnemius of the cat. Eccles, J. C., and Sherrington, C. S. Number and contraction values of individual motor units examined in some muscles of the limb. *Proc. roy Soc.*, 1930, B106, 326.

[3] Creed, R. S., Denny-Brown, D., Eccles, J. C., Liddell, E. G. T., and Sherrington, C. S., *Reflex activity of the spinal cord*, p. 8. Oxford: The Clarendon Press, 1932. Two methods of measuring the contraction are common: An *isometric* record is obtained when one end of the muscle is fixated, and the other practically so (as when it is attached to a very stiff spring). The record is thus one of increasing tension. An *isotonic* record is obtained when the load at one

persistent contraction is called "tetanus." When the stimulus is applied to the sensory side of the arc the rhythm of the break shocks does not show until their rate falls below 50 per second. Secondary waves and after discharge account for this obscuring effect of the center.

The nearest approach to the muscle twitch, offered by a voluntary movement of the intact organism, is found in the high-speed "ballistic" strokes made in rapid typing, piano playing, beating a rhythm, rapid tapping movements. All these show a burst of activity in the action-current records, lasting for 45 to 50 milliseconds. Even when the electrical stimulus is applied directly to the motor nerve, no matter how brief its duration, the action currents occupy about 20 millisec. Slow, tense movements (or fixations, in which a limb is held rigidly by the opposed contraction of antagonists) are obviously all of the tetanic type. Thus, even the most rapid voluntary jerk or flick of a muscle is shown to be aroused by a volley of impulses. The distinction, therefore, between the most rapid phasic contractions and the slow, tense, sustained tetanic contraction is thus one of degree—so far as the individual muscle is concerned. There are, however, other relationships which need to be noted.

Arrangement of the Muscles.—Let us return, briefly, to questions of structure. Beyond the muscle fibers the connective tissue is commonly prolonged into a cord or broad band which is attached to the bones or other organs to be moved. Where the muscle moves a bone about a joint, its origin (stationary attachment) is on the opposite side of the joint from its insertion (the moving end), thus forming a lever with the joint as fulcrum. Flexors and extensors are grouped about the joint so that their combined action will fixate the limb and alternate action will move it to and fro. In terms of a coordinated movement of a limb we may speak of pairs of muscles as (1) agonists (prime movers), (2) antagonists (opposed to 1), (3) synergists (acting with 1), (4) fixators. The fourth group serve to fixate a joint when it is to serve as a base for a movement in the distal member. Thus a movement of the forearm may demand a fixation of the upper arm, and the latter will be accomplished by the con-

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end is so light that it easily follows the course of the shortening. In the latter case a moving lever records the course of the contraction. The electrical changes in the muscle itself (action currents) are amplified and photographed with the aid of an oscillograph.

tinuous contraction of the antagonistic groups around the shoulder joint.

Types of Movements.—In terms of these muscular arrangements we may speak of two main types of movements: (1) slow, tense movements, in which the antagonistic groups oppose each other, and (2) ballistic movements, in which a brief pulse of contraction sets the limb swinging freely with no opposing action in its antagonist. The first group is shown in our stationary postures (the "movement of holding still") and in slow-moving "fixations" where one of the opposed groups yields to the greater contraction of the antagonists, both groups continuing to act (as in a slow pursuit movement or in carrying a vessel full of liquid which one is trying not to spill). The second group is illustrated in a rapid tapping movement. Records of contraction and movement show that the action of the two groups, flexors and extensors, is staggered (while the flexors contract the extensors are relaxed). The limb is thus thrown back and forth between opposing pairs of muscles. The muscle group which catches the limb also returns it, and with the same contraction. There is a definite upper limit beyond which such repetitive movements cannot be driven (*ca.* 10 per second), and any complex movement pattern (writing, typing, piano playing, speaking) will undergo "breakdown" if one attempts to force the parts beyond this limit. Interestingly enough, the 10 fingers do not raise this upper limit to 100 per second. If they are used in striking piano keys, for example, as speed is increased the movements tend to fuse, and a maximum of around 20 strokes per second sets the upper limit. In this respect our effector systems are inferior to those of the insects, whose beating wings may achieve rhythms of 300 per second.

Fatigue.—Continuous or rapidly repeated contraction of a muscle alters its irritability. If curves of successive contractions are superimposed (Fig. 43), four changes will be noted: (1) an initial spurt showing increase in strength of the contractions, (2) subsequent decline in strength, and an increase in latent time, and (3) in the later responses a slower return to the original length. Although inexcitable, the muscle is not "exhausted" and may remain in a state of partial contraction for a considerable time. Thus, a subject who has been instructed to lift a weight with his index finger at a rate set by a metronome is finally unable to move the weight, and at the same time he may be conscious of a tension in the forearm muscles. This sense of strain will arise from the proprioceptors in the tense

muscle and tendon. Even more telling evidence of such persistent contraction in fatigued muscles is provided by action-current studies. Stetson and Bouman showed that in "dynamometer tapping" the antagonistic muscle groups cleared each other with little or no opposed contraction in the earlier and easier stages of the task, but with the onset of fatigue opposed tensions appeared, continuing when the movement could no longer be executed. The action-current deflections were quite irregular and showed no recurrent rhythm, and seemed to indicate that the motor units (fibers innervated by one motor nerve) are ceaselessly acting in asynchronous fashion.[1]

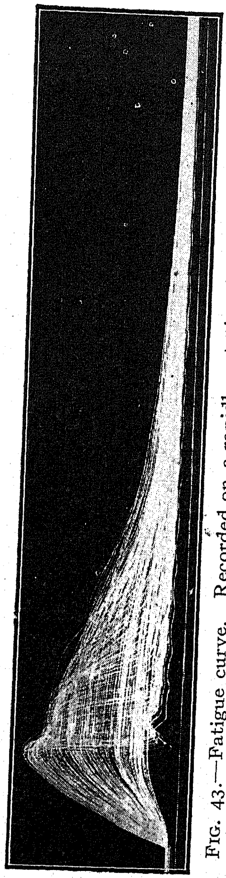

FIG. 43.—Fatigue curve. Recorded on a rapidly rotating drum. The muscle (gastrocnemius of frog) stimulated once per revolution. All contractions recorded. Reduced in reproduction. (*From C. G. Rogers. Text-book of comparative physiology, p. 403. New York: McGraw-Hill,* 1927.)

"Fatigue" has been related to the chemical products released by the contraction process (CO_2, lactic acid, acid phosphates, etc.). If extracts from a fatigued muscle are injected into the circulation of another fresh animal, the latter will likewise show a loss of irritability. Since anything which blocks the circulation both robs the muscle of necessary chemicals and prevents the removal of the fatigue products, we can readily see why venous stasis (produced by tourniquet) speeds the onset of fatigue. Fatigue of a muscle is thus attributed to a depletion of the energy supply of the muscle (contraction using up stored materials) and to the accumulation of the chemicals liberated by the contraction process. Recovery from fatigue, on the other hand, follows a rest period during which the depleted substances are restored and the fatigue products are removed; and if contractions are properly spaced, the processes of repair will balance the breakdown process and contractions may continue indefinitely.

[1] Stetson, R. H., and Bouman, H. D. The coordination of simple skilled movements. *Arch. néerl. Physiol.*, 1935, 20, 177–254.

Exhaustion vs. Blocking.—Certain questions arise at once. Obviously we cannot look upon fatigue as a simple exhaustion phenomenon, for the action-current studies show clearly that the muscle is far from being in a resting state. And there are other experimental findings which point in the same direction. If the demonstration of fatigue is made with a nerve-muscle preparation, when the point is reached where stimulation of the nerve fails to elicit a response application of electrodes directly to the fibers of the muscle restores contractions. Since it can be shown that the nerve still conducts impulses, it has been customary to refer the "block" to the area about the end plate, and attribute it to a local concentration of the fatigue products. Lapicque found that the chronaxie of the muscle had doubled (or trebled) and employed this fact as an explanatory principle (heterochronism). Certain it is that fatigue means altered irritability and not exhaustion.

We should remember, too, that the intact organism presents additional complications. Fatiguing a reflex and fatiguing a nerve-muscle preparation are not identical processes. Sherrington showed that when the "flexion reflex" (evoked by stimulation of a toe pad of the spinal dog) had been reduced to an irregular phasic tremor, the flexor muscles contracted promptly to the stimulus for the "scratch reflex." Or, a fatigued scratch reflex promptly reappeared when the stimulating electrode was moved to a point 2 cm. away. Thus a muscle which refuses to respond to one stimulus may still be accessible to another.

On a still higher level (passing from Sherrington's spinal animal to the intact organism) a muscle group may be available for reflex action but not for voluntary action. The arm that is fatigued in the dynamometer-tapping experiment may respond to reflex stimulation. And the phenomena of aphasia, as sketched by Hughlings Jackson, point to a similar distinction between voluntary and automatic habits. When fatigued, we can perform routine intellectual activities but fail at the more complicated and variable ones. Our conversation may employ the same speech mechanism, but its descent to banalities, clichés, and automatic verbal sequences distinguishes it from our better performance. These observations prompt one to present the fatigue problem in terms of "levels" ranging from chemical changes in muscle to a disintegration of our most complex habits.

Do these seemingly diverse types have a common basis? Does the chemical change in the muscle, induced by repeated stimulation,

lie back of all these phenomena? The generalization is tempting, and certain facts persuasive. For example, the metabolic changes in nerve are minute and neural fatigue is negligible. Long before the conductors fail, the "fuse" at the neuromuscular junction fails. In fact, neither nerve nor muscle is depleted. It is, rather, a change in the relationship between the parts, such that transmission from one to the other is no longer possible, a failure in resonance rather than exhaustion. The effectors are simply less available. The existence of action currents (as in dynamometer tapping) suggests that a local autonomy has been set up, that fibers continue firing in response to proprioceptive stimulation, and that the normal voluntary innervation is simply unable to break into this stream and capture the effectors.[1]

Certain resemblances between the simpler cases of neuromuscular fatigue and the behavior of the fatigued person may be worth pointing out. Just as new (or more intense) stimuli are able to arouse the fatigued muscle, so martial music revives the fagged troops on the march. And just as stimulation of the fibers of the sympathetic supply of the muscle (or injection of adrenalin) will decrease and delay the onset of fatigue in a muscle, so under the stress of emotion (anxiety, anger) an individual keeps active in spite of waning reserves of energy. The endurance of the mother through the illness of her child and the feats of strength and endurance of the panic-stricken (and the central branch of the autonomic system is active in both instances) are cases in point. Again, where two reflexes are opposed (antagonistic muscle groups) the fatigue of one gives its opponent an advantage when they are jointly stimulated. In the same way when we confront a situation our "attention" plays freely over it, the originally dominant response being replaced as repeated "firing" raises its threshold, one response thus giving way to another.

And the inability of the fatigued muscle to relax reminds one of the overtired person who finds that his sleep is interrupted with starts, tossing, groans, and fitful dreaming. The clinical description of nervous exhaustion likewise speaks of *both* the inability of the

[1] The alternate possibilities which have been suggested posit some type of central inhibition, synaptic or neural fatigue, placing the causes of "mental fatigue" in their familiar home. Any explanation for all the facts must be regarded as speculative at the present moment, and whatever hypothesis suggests the clearest line of experimental attack, the livest.

patient to initiate action and the inability to relax. The very posture and gait, the tense jaws and labored speech, show the neuro-*muscular* character of this "mental" state. Why we should refer to such patients as "nervous"—thereby implying that there is *either* nervous hyperactivity or that some nerve substance, on the contrary, has been depleted—when the visible symptoms are more obviously muscular than neural, can best be understood, perhaps, if we recall our animistic heritage. The very fact that one speculative account will refer to a *depletion* of nervous energy and another will speak of *hyperactivity* shows the parlous state of such theories.

Fatigue and Conflicting Responses.—Many fatigue phenomena are clarified when we recall the arrangement and functioning of antagonistic muscles. In the properly timed movement the antagonists clear for each other and our strokes are freely flung, without opposition. The novice who has not acquired the skill (and the timing), on the other hand, sets one antagonist pushing against the other. His work requires more energy and is more fatiguing. Hence it is that the teacher of piano must strive to get loose wrists, elbows, shoulders; otherwise the performance will be stiff, arhythmic, and if practice is intensive, the pupil will develop persistent, fatiguing (and even painful) contractures (piano arm). Similarly, the industrial engineer, the instructor in golf, in fact, anyone who is concerned with efficient performance in a skill, will find sources of fatigue as well as faults of style of execution in the timing of opposed muscles; and whatever he can accomplish in the direction of converting the slow, tense movements, where one antagonist contracts against another, into the rapid, freely thrown, ballistic movements will be in the direction of efficiency.[1]

On a social level, by an extension of the same logic, we may describe the so-called conflict situation, which all will agree is exhausting, as occasions in which each line of action has to be worked out against a musculature that is also mobilized for opposite actions. The person with divided loyalties finds living a difficult task, and actions which would be easy for another are for him energy consuming. On the other hand, when he has reached a decision, and has finally thrown

[1] The case of the stammerer is worthy of development in similar turns. Another example is afforded by the runner who gets his "second wind," thereby losing the pain in his side as the opposed action of muscle groups involved in running and breathing is replaced by a better timing.

his lot upon one side of the issue, he experiences a release of energy and may speak figuratively of an "oppressing weight" that has been lifted. He speaks of "breathing more freely," and if our view of the matter is correct, his subjective account of the matter has a solid muscular basis.

Tonus.—In contrast to the concentrated volleys of motor-nerve impulses and the simultaneous "explosions" of a large number of fibers (as in beating a rhythm), the moderate and persistent tensions which make up a normal muscle tone are composed of a random series of pulses and sporadic and alternating firing of small groups of fibers. The total volume of contraction is less, and the firing is not synchronous; but the contractions in the fiber units are not different in the two types. Although the antigravity muscles will show the greatest amount of continuous tension, all muscles will show this random and continuous firing.

It was formerly believed that muscle tonus was in large measure attributable to the action of the autonomic fibers which penetrate the striped muscles, but present evidence indicates that the action of the autonomic fibers is indirect, through changes in the circulation of the muscle. According to Forbes, cutting the motor fibers from the central nervous system will remove all contractions, phasic and tonic; stimulation of autonomic fibers does not induce contraction, nor does their severance destroy tone. It would seem, therefore, that the function of the autonomic fibers is to regulate the flow of blood through the muscle by their action on the smooth-muscle walls of the small blood vessels.

The tone-maintaining stimuli arise, in part, within the muscle itself, the proprioceptive endings in the muscle and tendon firing off reflex circuits through spinal centers which return the impulses to the muscle itself. The semicircular canals, other muscles, both striped and smooth, all receptor surfaces, will provide afferent tonus-regulating streams. The cold air striking the skin on a frosty morning, lights, sounds, contacts, all will contribute, and their effects will vary with the physiological state of the responding fibers. The tone-regulating conditions are complex enough, but no separate mechanism is required.

Voluntary and Reflex Contractions.—Without attempting to develop at this point all the implications of the term "voluntary," a brief examination of certain features which have been noted in the curves of response of these two types of reaction may help us to form

a tentative definition. Some investigators[1] have pointed out that the voluntary reaction develops more slowly, persists longer, and has a longer reaction time. Thus, if we ask a subject to give a voluntary eyewink in response to a light stimulus, most of his reaction times will fall within 100 to 200 millisec. If we record the time of his reflex winks to shock, a sound, a puff of air, it will fall between 45 and 65 millisec. Schlosberg found that when he compared the reflex knee jerk with a voluntary kick the latter was not merely slower, but the form of the curve of response showed that the voluntary reaction developed more slowly and lasted longer than the speedy flick of contraction in the reflex jerk. But it is also true that under proper conditions (*e.g.*, rapid repetition of a simple tapping movement) the voluntary contractions look very much like the reflex records. Varying the intensity and duration of the stimulus for the reflex also alters its form: instead of an abrupt momentary flick of the eyelid (produced by the noise of a spring rattrap released near the ear of the subject), one can obtain a slower and more persistent contraction by substituting a moderately intense but steady stream of air against the cornea.

It seems probable, therefore, that the only valid distinction between the two types of reaction which can be made at the present time is the difference in reaction time. It is possible that the differences in form which have been noted in the literature may have arisen from the particular patterns of stimulation which gave rise to the movements studied. The commonly accepted explanation for the difference in the reaction times has been that the reflex is mediated by a direct neural connection through spinal or brain-stem levels, whereas the voluntary response involves higher level neural arcs, longer paths, and a larger number of synaptic crossings. The fact that the reaction time of the voluntary response is so often at least twice that of the reflex suggests the possibility that what we call a voluntary response is (among other things) a *reaction-to-a-reaction* and that the response which first registers the signal also initiates (through proprioceptive paths) the final reaction which is recorded. The instruction stimulus which sets up the subject's intention to respond (preparatory posture) would thus be looked upon as setting

[1] Schlosberg, H. A. A study of the conditioned patellar reflex. *J. exp. Psychol.*, 1928, 11, 468–494.

Peak, Helen. Modification of the lid-reflex by voluntarily induced sets. *Psychol. Rev. Monogr.*, 1931, 42, No. 1, 68.

up this registering group of effectors so that when the final stimulus comes it may rebound from this group into a particular efferent pathway. These speculations also suggest a second reason for the frequently noted duration of the voluntary response, since such a proprioceptive stimulus pattern is less likely to have the abruptness which would characterize the condenser discharge or the sound of the sprung rattrap.

Smooth Muscle

Smooth muscle is found in the walls of the hollow viscera (arteries, veins, esophagus, stomach, small and large intestine), in the genital and urinary organs, in the eye (iris and ciliary muscle), in the skin (attached to the hair follicle), etc. It is composed of minute, elongated cells (40 to 250 μ in length, and 5 μ in thickness) within which there are fibrils. The latter are said to continue from one cell to another and, like the fibrils of the striated muscle cell, to be the contractile agents. These cells are arranged in sheets, tubes, and pouches and carry on movements which are extremely important in maintaining the life processes. They regulate the blood flow (constriction and dilation of the walls of the blood vessels), perform the churning movements of stomach and intestine, empty the bladder, etc., in automatic fashion. Because they do not respond to our "intentions" in the manner of the striped muscles they are sometimes referred to as the "involuntary" muscles.[1]

The smooth muscles are supplied with postganglionic fibers from the autonomic system, a double innervation ensuring both relaxation and contraction (according as sympathetic or parasympathetic systems are involved). Thus, stimulation of the sympathetic division inhibits intestinal smooth muscle and accelerates the heart;[2] stimulation of the parasympathetic division slows the heart and increases intestinal action. The inhibitory type of stimulation produces a relaxation and lengthening of the fibers, lessening or abolishing any preexistent contraction. Because it is known that the

[1] The experimental study of Hudgins demonstrated that the pupil could be "educated" so that it would respond to commands (or to subvocal "thoughts"). Hudgins, C. V. Conditioning and the voluntary control of the pupillary light reflex. *J. gen. Psychol.*, 1933, 8, 3–51. The voluntary control of the sphincters of the bladder offers another illustration of the limitation of the conventional description.

[2] The heart is not classed as smooth muscle for reasons of structure although it closely resembles the latter in function.

smooth muscles have the power to maintain their tone (or to beat rhythmically) over long periods even when completely severed from all nerve supply, the inhibitory process is seen to involve more than mere cessation of stimulation. Recently evidence has accumulated to show that stimulation of the sympathetic division liberates in the muscle a substance similar to and possibly identical with adrenalin. There is also evidence that parasympathetic stimulation releases acetylcholine (and injection of this substance reproduces the effects of parasympathetic stimulation). Other chemicals carried by the blood stream (and secreted by the ductless glands) are known to affect smooth muscle, particular products affecting particular muscle groups in a characteristic manner. For example, pituitrin—an extract of the posterior lobe of the pituitary gland—slows the heart rate, contracts arterioles, constricts the uterus, relaxes bronchial muscles.

Smooth muscle reacts to mechanical stimuli (pinch, blow, tension). If tension is increased gradually, the muscle will first relax and then contract sharply. If, for example, the bladder of an experimental animal is isolated from all nervous connections and gradually filled with fluid, the organ will expand to accommodate the fluid, but when the pressure begins to rise sharply, rhythmic contractions are released.

Electrical stimuli also produce contractions. The responses are of longer duration and greater latency than those of the striped muscles.[1]

As a result of the slow character of the response, summation and tetanus occur more readily (one stimulus in 5 sec. will produce tetanus in a frog's stomach muscle). Smooth muscles maintain their tone over long periods in such an economical fashion that the physiologist finds little that is analogous to the fatigue of striated muscle. Although smooth-muscle tone is altered by the nerve impulses which reach it, there is a degree of independence not exhibited by striated muscle. Even when out of the body it continues to exhibit tone, and in some instances it will beat rhythmically, as in response to tension.

The Endocrine Glands

Within recent years the developing science of endocrinology has drawn attention to a different type of effector. Nerve impulses

[1] The latent period may vary from 0.2 to 0.8 sec., and contractions will last up to several minutes.

reaching secretory cells in glandular tissues may either increase or decrease their activity, thereby altering their chemical output. The released chemicals are poured, in some instances, into ducts which carry their products to the surface of the body (*e.g.*, lachrymal and sweat glands). In other cases they discharge into the alimentary canal, playing a role in digestion (salivary, gastric, pancreatic, and intestinal glands). A third type throws its secretion directly into the blood stream and it is thus transported to remote parts

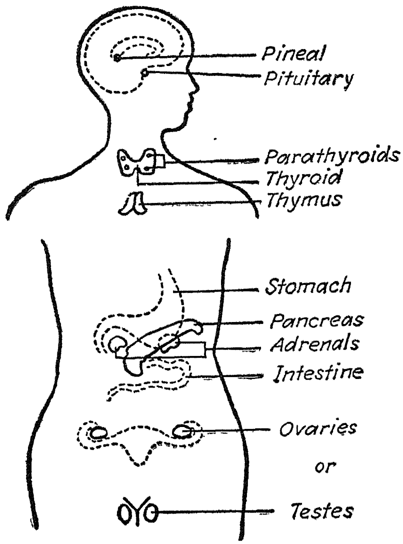

FIG. 44.—Silhouette of human figure showing location of the endocrine organs. (*From R. G. Hoskins. Tides of life, p. 19. New York: Norton, 1933. By permission of the publishers.*)

of the body. Although the quantities of the secreted material, in the latter case, are extremely small, they are of great biological significance.

These glands of internal secretion serve as regulators, "pacemakers," altering growth and general reactivity; and in the case of the gonads, profoundly alter the whole pattern of behavior. In the pages which immediately follow we shall summarize, briefly, the principal findings with reference to four of the ductless glands: adrenals, thyroid, pituitary, and gonads.[1]

[1] Other glands (pineal, thymus, pancreas, spleen, parathyroid, salivary, gastric, etc.) might well be included. Their exclusion was dictated in part by the exigencies of space, in part by their more limited function (*e.g.*, salivary,

The Adrenals.—Since the description of Addison's disease (1855) the adrenal glands have occupied the attention of medical men. The symptoms which Thomas Addison described included: asthenia (loss of strength, languor, debility), bronzing of the skin, feeble and irregular heart, failure of the appetite, and general irritability of the gastrointestinal tract. All these were traced to disease of the suprarenal glands, in most cases a form of tuberculosis. There are two glands, each weighing about 4 g. and approximately 3 cm. in length and breadth and 8 mm. in thickness. Each gland rests on the upper pole of a kidney like a small conical hat. Two portions may be distinguished with the naked eye, a yellow outer rind (cortex) and a red central portion (medulla). The glands are richly supplied with blood, receiving six times their own weight in blood each minute. Both parasympathetic and sympathetic fibers innervate the glands, the sympathetic serving to increase their secretory activity.[1]

Adrenal Cortex.—Removal of the cortex of the gland proves fatal: loss of weight, weakness, lowered temperature and metabolic rate, passing rapidly to prostration and death. Conversely, in Addison's disease (where the whole gland is affected) administration of cortical extracts alleviates many of the symptoms. Although a substance, cortin, has been isolated, its chemical properties are undetermined thus far and its physiological action remains to be explained. In addition to the rather dramatic alleviation of the symptoms of adrenal deficiency, clinical studies have shown that cortin has a pronounced effect upon growth and development of the sex glands. Excessive development (tumors of the cortex) may produce precocious development of the body as a whole, and of the reproductive system in particular. Thus a boy of 7 with a child's stature is described as having the voice, muscles, and reproductive system of a man. The female child so affected is also precocious, but as development progresses she tends to become a caricature of masculinity, with male voice, facial hair, atrophied breasts, etc.

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gastric), and in part by the lack of any clear-cut experimental evidence (thymus, pineal).

[1] The secreting cells of the medulla may be described as the morphological equivalent of postganglionic neurons, for they arise in the embryo from the same type of cell. These cells are directly activated by preganglionic fibers, thus violating the usual autonomic arrangement. Their further intimate connection with the sympathetic system is shown by the close parallel between the action of adrenalin and that of the sympathetic system.

The Adrenal Medulla.—The adrenal medulla secretes a substance known as adrenalin, whose properties have been extensively investigated by physiologists. Closely resembling the action of the sympathetic system, adrenalin produces striking and widespread effects: dilation of the pupil, protrusion of the eyeball, increase in rate and force of the heartbeat,[1] relaxation of bronchi,[2] inhibition of the smooth muscles of the intestinal wall, and constriction of sphincters, conversion of glycogen stored in the liver into glucose, contraction of spleen, uterus, smooth muscles of the skin, and widespread circulatory changes. Constriction of blood-vessel walls forces blood from the abdominal viscera and from the skin surface into the region of the striped muscles, and is a factor in the rise in blood pressure. Adrenalin counteracts "fatigue" and in general speeds up oxidative processes in the tissues. Increased muscular efficiency is due in part to an increased blood supply (with its oxygen and freshly liberated glucose) and possibly to a more direct action of adrenalin upon the tissues of the muscle fibers. The picture presented is one of an energizing chemical whose effects put the organism on a "war footing." Even the rate at which the blood clots is speeded.

It is probable that adrenalin is always present in the blood stream in minute quantities and that any slight exertion causes some increase in adrenal activity. More intense stimuli release adrenalin in amounts which produce measurable changes for at least twenty minutes afterward. Thus Cannon and Britton found that the denervated heart of a cat increased 30–80 beats per minute when excited by a barking dog, and that the acceleration could be detected twenty minutes later. In spite of the fact that removal of the adrenals did not abate the cat's excitement in response to the same type of stimulus, the subsequent disturbance had disappeared within five minutes. Exposure to cold, sudden fall of blood pressure, hypoglycemia (low blood sugar), asphyxia, and all stimuli arousing strong emotional responses are known to activate the adrenals. The power of the chemical which is liberated may be indicated by the

[1] In the intact animal the increase in heart rate is speedily checked by vagus reflexes originating in the distended aorta and the heart is actually slowed. In the denervated heart both rate and force are increased.

[2] The relaxation of these branches of the trachea forms the basis of the use of adrenalin in the treatment of bronchial asthma.

low concentrations of the chemically pure drug which will still produce measurable physiological effects (1:300,000,000).

The Thyroid Gland.—The thyroid (literally, shield-shaped) gland consists of two lobes, lying on each side of the larynx and trachea, and an isthmus or connecting lobe. The glandular tissue is deep red, and varies in weight from an ounce upward, reaching as much as a pound in goiter cases. Microscopically it is seen to be composed of many little sacs lined with secreting cells. A jellylike colloid, rich in iodine, fills the intervening spaces. The gland is generally larger in women and children than in the adult male.

There is a rich blood supply, and the gland is innervated by the vagus and by fibers from the cervical sympathetic, the nerves serving to control both blood supply and the activity of the secreting cells.

The active principle of the gland, thyroxine, was isolated by Kendall (1915) as a pure crystalline compound, and like adrenalin the latter was found to produce remarkable physiological effects: one milligram, for example, raising basal metabolic rate 3 per cent. Added to the water in which tadpoles are developing, growth and metamorphosis are speeded (gills and tails wasting away) and a transformation which normally occupies two to three years (in the bullfrog) can be crowded within a two-week span, producing frogs as small as flies. On the other hand, deprived of their thyroids, they remain as tadpoles though they become large and sexually mature.

Like a catalyst which speeds chemical reactions, thyroxine alters all those physiological changes which figure in the action of muscle and nerve. The total amount active in the body at one time is very small, probably as little as 12 mg. (1/5 grain) and in the course of a year but 3½ grains will be used; yet the presence or absence of this minute quantity spells the difference between normality and imbecility in the developing child.

Thyroid Deficiency.—A congenital absence or maldevelopment of the gland in the prenatal period may not be apparent at birth, owing to the continuing influence of a normal supply from the maternal blood (or milk), but by the sixth month it will be apparent that the development of the child is not progressing normally. He will be slow in holding his head erect, in sitting, walking, and speaking, and—unless early relief is given by administration of glandular extracts (or thyroxine)—mental development will never achieve normal levels. The whole body finally registers the defect: bones

are small and skeleton is stunted, secondary sex characters do not develop, the skin is dry, cold, thick, lifeless, hair is harsh, dry, and falls out readily, teeth are poorly formed and slow to appear, the face is puffy, and the thickened upper eyelids, lips, and protruding tongue give an appearance of sleepy idiocy, hands and feet are broad and clumsy in appearance, the muscles weak and poor in tone. Stunted, potbellied, weak, sluggish, the cretin seems to portray a slowing down of the whole developmental process, as though the "fires of life" had been damped down. Even the temperature is subnormal. Yet if proper corrective measures are taken within the early months a near-normal development is possible.

Thyroid deficiency in adults (myxedema) may follow operative removal of the gland, or may occur "spontaneously" (*i.e.*, from unknown causes) from the atrophy of the gland.[1] Body temperature falls (as much as $3\frac{1}{2}°$) and the patient complains of cold. Although the appetite is "dainty," weight increases. There is a fall in energy output and both heart and respiration are slowed. Deposits of a peculiar, firm (myxomatous) tissue under the skin give a puffy appearance to the flesh, and rob the face of its normal expressiveness. There is a general decline in mental activity, as well as in all overt movement. Speech is slowed and "thickened," and the pitch of the voice lowered. Frequently the patient is forgetful, inattentive, lacking in initiative or in capacity to reach decisions. Easily fatigued, the hypothyroid is often both irritable and lethargic. There is commonly associated a depression or disturbance of sexual function: impotence in the male, and irregular or failing menses in the female.

Hyperthyroidism.—The symptoms of overactivity of the thyroid gland are, as we might expect, the opposite of the picture given above. Like certain forms of myxedema, the diseased condition (Graves' disease, exophthalmic goiter) often springs from unknown causes, but it is known that emotional stress aggravates the state, and it may be the primary factor at times. The general picture is one of "nervous" tension, and the protruding eyeballs[2] heighten this effect.

[1] The colloid goiter, in which the neck area is visibly swollen, involves an overdevelopment of thyroid tissue but is accompanied by signs of hypothyroidism. It is commonly described as a type of glandular compensation, and is believed to arise from iodine deficiency. Administration of iodine (thyroxine contains 65 per cent iodine) in proper dosage is recommended as a preventive measure.

[2] This protrusion is said to be due to heightened tonus of the smooth muscles of Tenon's capsule (protrusor bulbi).

Metabolic rates increase, heart and respiration are speeded, weight falls, and there is excessive perspiration, an increase in muscle tone, and a noticeable fine tremor. Overexcitability, emotionality, rapid (and even "flighty") thought and overt movement are characteristic. Operative removal of some of the glandular tissue or administration of iodine has served as a remedial measure.

At a less extreme level, the hyperthyroid type described by Berman becomes a typical "man of action." They are "characterized usually by a lean body, or tendency to become thin under stress. They have clean-cut features and thick hair, often wavy or curly, thick long eyebrows, large, frank, brilliant, keen eyes, regular and well-developed teeth and mouth. Sexually they are well-differentiated and susceptible. Noticeable emotivity, a rapidity of perception and volition, impulsiveness, and a tendency to explosive crises of expression are the distinctive psychic traits. A restless, inexhaustible energy makes them perpetual doers and workers, who get up early in the morning, flit about all day, retire late, and frequently suffer from insomnia, planning in bed what they are to do next day."[1]

It is probably better to say that the man of action shows symptoms which remind one of the endocrinologist's description of hyperthyroid symptoms, for it is largely a matter of conjecture as to whether the type described by Berman actually gets more than the normal amount of thyroxine from his thyroid glands. Even if this could be demonstrated, we should want to know whether the level of glandular activity was primarily an affair of bodily constitution, of diet, or of the variety of social or economic pressures under which the individual is operating. These considerations should warn us against a too facile translation of physiological symptoms into "personality types," and against a too limited "chemical" interpretation of human behavior.

The Pituitary Gland.—The pituitary gland lies at the base of the brain, to which it is connected by a funnel-shaped neck (*infundibulum*) which passes upward just behind the optic chiasma. Like a small cherry, weighing about 0.6 g., it fits neatly into a hollow in the bony cranial floor in front of the brain stem. Two lobes are commonly differentiated: (1) a larger anterior lobe with large glandular cells permeated by enlarged capillaries; (2) a posterior lobe

[1] From Berman, Louis. *Glands regulating personality.* Reprinted by permission of The Macmillan Company, publishers.

consisting of vesicles and secreting cells (*pars intermedia*) and neuroglial supporting cells (*pars nervosa*), which provide a reservoir for secretions of the *pars intermedia*. According to Hoskins, there are in all probability at least eight different hormones produced by this gland, and if one thinks of but three levels of functioning for each hormone (normal, hyper, and hypo functioning) it will be seen that the endocrinologist faces an enormous task in isolating clinical types which represent all the possible combinations of functioning. At present it is possible to indicate only the major outlines.

Anterior Lobe.—The anterior lobe produces growth-stimulating, ovulation-regulating hormones. Extirpation of this lobe in experi-

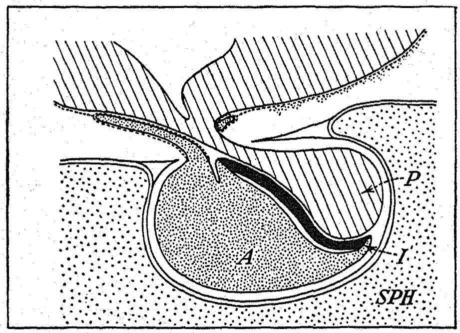


Fig. 45.—Diagrammatic drawing of the pituitary body. *A*, anterior portion; *I*, intermediate portion; *P*, posterior; *SPH*, sphenoid bone. (*After Atwell. From E. M. Geiling. Chemistry in medicine, Chap.* VI, *The hormones of the pituitary secretions, p.* 241. *New York: The Chemical Foundation. By permission of the publishers.*)

mental animals produces dwarfs, and subsequent injection restores growth. Injections into normal rats for 333 days produced animals weighing 596 g. (as compared with 248 g. for a control group). Bones and viscera share in the growth. There is evidently a relationship between the pituitary action and sex, growth being greater in females than in males, and greater in both sexes if the gonads are removed. Gigantism occurs in the human being if the overfunctioning of the pituitary develops before bony growth is completed, and there are records of individuals who have grown to 8 and 9 ft. in height. If the disease sets in later in life, a condition known as *acromegaly* results, showing: overdevelopment of jawbones, widely spaced teeth, increased size of hands and feet, coarsening of the features, bowing of the spine. The bent back, heavy jowl, large

low-hanging hands, make the individual a veritable "gorilla type." Hoskins lists the following mental characteristics as common symptoms of the acromegalic: irritability, moodiness, absent-mindedness, inability to concentrate or get hold of oneself, (and in later stages as the secretions begin to fail) apathy, stupor, loss of memory, and mental sluggishness. Corresponding to early hyperpituitarism (and later failing secretions), there is an early acceleration and later suppression of sexual functioning, and a loss of sex drive. In the male the anterior lobe appears to control the development of reproductive organs, and in the female it initiates the cyclic changes in the ovary and plays a role in regulating these during the active sexual period.[1]

The Lorain type of dwarf, owing to failure of the anterior lobe (and hence of the growth hormone), is physically like an attractive, well-formed child.[2] These dwarfs are usually sexually immature also, although occasionally they have been known to marry and produce normal offspring.

The Posterior Lobe.—The hormones supplied by the posterior lobe stimulate heart muscle, constrict capillaries, and in general cause smooth muscle to contract. Two principles have been segregated: vasopressin, which acts upon blood vessels, and oxytocin, which stimulates the uterus. Hoskins suggests that normal intestinal tone may depend upon a constant supply of the stimulating principle from the posterior lobe. In addition, there are important changes in metabolism which accompany disturbances of the posterior lobe. Underfunctioning leads to excessive flow of urine (as much as ten gallons daily) and excessive fat is deposited. Dickens's Fat Boy, beardless, rotund, slothful, appears among the hypopituitary types.

A general underfunctioning of the pituitary may therefore produce: stunted growth, retardation or depression of sexual function, increase in weight, slowing of mental functions, lowered metabolism (with associated lethargy), slow pulse, drowsiness, polyuria. Over functioning would be characterized by gigantism (or acromegaly) precocious and hyperactive reproductive structures (save in the later stages when tumors have brought about an underfunctioning).

[1] *E.g.*, anterior pituitary transplants will induce precocious ovarian activity in immature mice.

[2] The Lorain type of dwarf is to be distinguished from the cretin, and from the achondroplastic type (muscular, squat, bowlegged, resembling a telescoped adult). The cretin is always retarded mentally, the other two are normal.

Gonads (Sex Glands).—In addition to their function in reproduction, the gonads furnish internal secretions which have marked consequences for development and behavior. Directly or indirectly they are important agents in the development of all that goes to make up masculinity and femininity; both body structure and comportment are profoundly altered by early castration. Cattlemen, who castrate thousands of animals annually, do so not so much because of the ensuing docility as to make them grow to a larger size, and take on weight; but the behavior differences are quite as noticeable as the altered metabolism.

Male Gonad (*Testis*).—The ovoid testis is composed of minute tubules, lined with cells which produce spermatozoa, and of the interstitial cells (of Leydig). It is the latter group which produces the hormone that is absorbed into the blood stream.[1] Removal of the gonads before puberty prevents the development of the rest of the reproductive apparatus, and the secondary characters fail to appear. The voice remains high-pitched, there is no growth of hair on face, axillae; pubic hair conforms to the female pattern. The individual grows tall, the long bones increasing in length into the third decade, and there are some indications of thyroid deficiency. In addition, there are often deposits of fat about the hips and breasts, and muscles are noticeably flabby, weak. Several experimental studies of castrated animals have shown a marked decrease in spontaneous activity following the operation. Both sexual desire and normal male aggressiveness fail to develop.

If gonads are removed after puberty the changes are less striking. Sexual feeling is commonly lost, but there are no skeletal changes. Many of the changes which come with senility may be attributed to atrophy of the gonads. According to Voronoff, testicular grafts in senile animals induce a return of vigor, both sexually and in general bodily function, and some enthusiasts have held out hope for a general prolongation of youth and the banishment of our fears of invalidism, impotence, and the general decline of old age. The majority of physicians are hesitant, however, for the gland grafts seldom persist for any great period. There is reason to believe,

[1] Marked eunuchoid types may possess normal spermatozoa and "virile" body types may lack true reproductive cells. Ligation of the *vas deferens* (outlet from seminiferous tubules) produces degenerative changes in the true sex cells, and renders the individual sterile. It does not, however, induce the bodily changes of castration.

moreover, that the atrophy of the gonads is neither the sole nor the primary factor in bringing on senility, and there is a real danger that —while the graft may stimulate sexual vigor and physical activity— the worn heart, arteries, etc., may find the new strains excessive.

In the description of human cases one finds accounts of adult castrates who show strong feelings of inferiority, general mental depression, moodiness and a tendency to morbid introspection, listlessness, sense of failure, etc. It is not possible, however, to be sure that these are simple and direct consequences of glandular loss. We are forced to distinguish, here, between an immediate physiological effect (such as lowered metabolism) and the psychological consequences which will flow from the recognition that he is not as other men, that others either despise or pity him, that he can never be a husband or father, etc. In fact, so potent are these socially conditioned attitudes that the adult castrate deserves his position as the paradigm of Adler's inferiority complex. There is, however, an important chain of causal factors (educational and social) which are totally neglected if we attribute such mental states to the simple absence of a hormone. Similar symptoms may arise without any such glandular basis simply because circumstances convince an individual that he is "not as other men," and depression and listlessness are by no means confined to failure in the sexual sphere.

The unraveling of cause and effect in this sphere is not an easy matter. Are we to diagnose all cases of abnormal eroticism (satyriasis) as due to a primary glandular hypertrophy? There is certainly no psychological justification for this: both present stimulation and past conditioning will alter the level of gonadal functioning. While all may agree that the gonads contribute their share to virility, aggressiveness, and to the emotions which arise in heterosexual love, and that the sexual period of the life cycle is largely if not wholly timed by a chemical developmental schedule, we fall heir to the part-whole fallacy when we forget that the functioning of these glands depends in turn upon conditions external to themselves. With equal gonadal endowment two individuals may live vastly different sexual careers, from both qualitative (directional) and quantitative standpoints.[1]

[1] This is perhaps a too cryptic way of stating that both the manner and the amount of sexual expression may vary independently of a given biological endowment. Moreover, it is well known that fear and anxiety may effectively suppress sexual functions, and experimental work with animals has shown that dietary

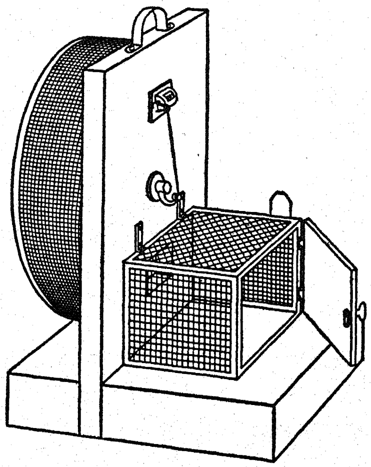
Female Gonad (*Ovary*).—In addition to its reproductive functions the ovary releases at least two hormones which have important roles in growth and in the regulation of the changes in the menstrual cycle, and in pregnancy. While the physiologist is inclined to be cautious in linking developmental changes to specific ovarian hormones, it is probable that prepubertal extirpation of the ovary would result in a "neutral" type, abnormally tall, with undeveloped reproductive organs and secondary sexual characters, and absence of menstruation. These changes are all found in animal experimentation, and in addition, reproductive "instincts" are absent. Postpubertal surgical removal is followed by atrophy of reproductive structures, cessation of menstruation, increase in weight. It is commonly reported that there is no change in sexual desire. Psychological changes such as irritability, resentment, self-pity, critical and hostile attitudes toward the environment offer a problem similar to that raised by the male castrate, for we are not dealing with a simple hormone deficiency, but rather with a profound change of status.

Animal experimentation shows a clear relation between the ovarian hormones and both strength and activity levels. A four-day cycle of activity parallels the oestrous cycle in the female rat, and spaying destroys the cycle and decreases muscular strength. Conversely, when ovarectomized females (or castrated males) are given the hormone through injections or gland grafts, the activity level is raised and the cycles established. The fact that gland grafts can establish the cycle in castrated males who never had showed such rhythmic changes is striking evidence of the regulatory powers of the hormone. It is equally certain that administration of the hormone restores sexual activity to ovarectomized animals. The data for human subjects is less clear.

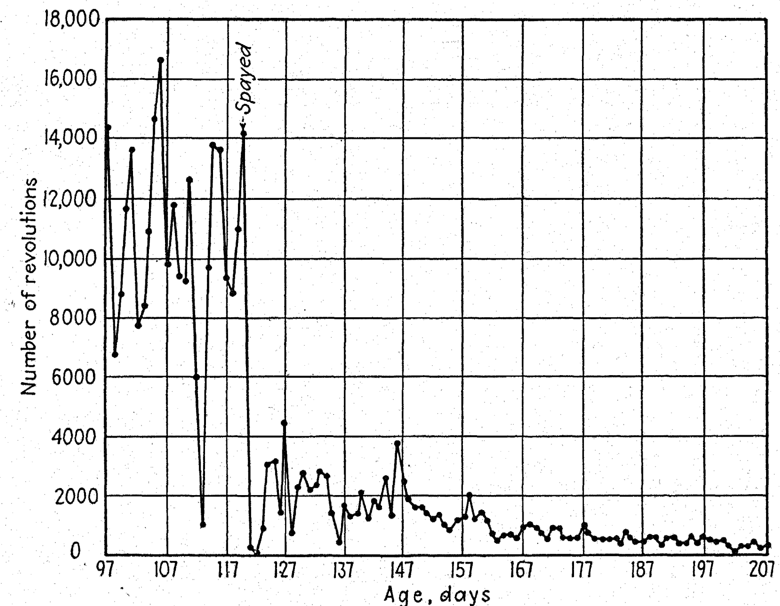
General Considerations

Just as the young medical student is prone to make premature application of his first training in pathology, the new science of endocrinology is sometimes prone to make hasty and superficial application of its findings. Kretschmer, Stockard, and Berman

deficiency (vitamins E and A) may postpone sexual maturity or depress functions already established. All these observations serve to remind us that there are regulatory conditions for the gonads themselves.



A



B

FIG. 46.—*A*. Revolving activity cage (Spaeth model). Food and water are provided in the small living cage. The activity of the animal in the revolving drum is registered by a Veeder counter which records revolutions in either direction. (*After a design by the G. H. Wahmann Manufacturing Company.*)

B. Curve showing the effect of complete removal of both ovaries. Abscissas, age in days. Ordinates, number of revolutions in the revolving drum. Note the marked drop in the activity of female rats at the time the ovaries are removed (spayed). (*From C. P. Richter. Animal behavior and internal drives. Quar. Rev. Biol.*, 1927, 2, 326. *By permission of the publishers.*)

have ventured to establish a typology founded upon their knowledge of endocrine function: and they seem to propose, at times, to explain the "person" in terms of the gland.

Thus, Stockard describes a tall, thin, dolichocephalic type as produced by an active thyroid, for the "rapid growers" tend to take the linear form. And he selects the thyroid as the gland known to affect growth and structure. Stockard is not content, however, to confine the description to structure; he adds such descriptive terms as nervous, active, energetic, self-conscious, to describe the behavior of the type. He describes these individuals as laughing rarely, as under rigid self-control, as more prone to shell shock, and adds: "The linear type is more adventurous and often embarks without hesitation on an unknown trail, a trait which has caused them to set forth and discover the continents and islands of the world, while the lateral type [hypothyroid] is more inclined to follow well-thought out plans and possesses a higher regard for details and preparedness."[1]

One is reminded of the naïve materialism of Feuerbach, who believed that the revolution of 1848 failed because the poorer classes had been made sluggish by their diet of potatoes. In his impatience, he exclaims, "Potato blood can make no revolution."[2] And one can imagine the modern social philosopher, impressed by the findings of endocrinology, explaining the rise of a Hitler by the prevalence of hypothyroidism among the Bavarian peasantry.

Kretschmer's sins in this respect are no less glaring. In a study[3] founded upon some 260 cases he divides humanity into three body types: asthenic, athletic, pyknic. The asthenic is a lean, narrow-shouldered, flat-chested individual, with flabby muscles—a general picture of weakness. The pyknic is a broad-shouldered, deep-chested individual—with chest broadening out at the base—a well-rounded figure, reminding one of the cartoonist's personification of opulence. The athletic type is the heavily muscled, broad-shouldered, narrow-hipped individual, whom we are wont to describe as well-proportioned. The endocrine basis of the types is left in an altogether nebulous form, but Kretschmer is certain that some

[1] From Stockard, C. R. *The physical basis of personality.* New York: Norton, 1931. Reprinted by permission of the publishers.

[2] Quoted by Sidney Hook in *Towards the understanding of Karl Marx.* New York: Day, 1933.

[3] Kretschmer, E. *Physique and character.* New York: Harcourt, 1925.

subtle chemistry of the blood is responsible and that the endocrines are the basic regulators. But most remarkable is his theory of the temperaments which are indissolubly linked with the body types, temperaments which—under stress—produce radically different types of insanity or, functioning at their best, different types of genius. He is prepared to explain the differences between the idealist and the "whole-hogger," between the metaphysician and the empirically minded scientist, between the realist and the romanticist, as merely so many manifestations of this basic "blood chemistry."

Since Aristotle tried his hand at physiognomy we have had a long succession of attempts to read "personality" from some simple bodily measurement. Now, phrenology and physiognomy find their successor in the hasty generalizations of a few endocrinologists, and today there seem to be those who believe that a pituitary failure made a Napoleon, and hyperthyroidism a Shelley. For those who are not so easily convinced it may be comforting to note that such fallacious reasoning usually falls of its own weight, and that when it does so the few supporting facts become all the more forceful when cleared of obscuring rubbish. It seems to the writer that the generalizations which are now being made about the relationships between endocrine disorders and crime, behavior problems in children, insanity, are likely to undergo similar deflation.

One further point deserves emphasis. The endocrines are all too commonly taken as primary factors, determined by heredity. It is also true that they are effectors, responding to stimulation, and as such their output must vary with external stimulation. Bissonnette has recently shown, for example, that increasing the hours per day during which light rays fall upon the retina of the female ferret modifies the sexual cycle.[1] The pituitary may regulate the onset of oestrus, but the gland itself is regulated. Moreover, glands, like all other effectors, are subject to the conditioning effects of experience: we secrete saliva at the sound of preparation of the meal, and secrete adrenalin at the announcement of approaching danger—when we are properly "conditioned."

Most of the glandular effects are nonspecific: the metabolic and structural changes affect all manner of activities. The sex glands offer the clearest exception to this description, although even here are diffuse effects. And it is true that the mere presence of gonadal

[1] Bissonnette, T. H. Modification of mammalian sexual cycles. *J. comp. Psychol.*, 1930, 16, 93–103.

hormones in the blood stream does not guarantee to their human carrier either a knowledge of their purpose or a willingness to be the agent of biological forces. However such matters may be determined for the animals, human beings often manage to achieve a profound ignorance regarding them, and by cultural devices to nullify the chemistry of nature or divert it into bizarre channels. Outside of the gonadal hormones, the endocrine substances are assuredly little more than pacemakers, giving us levels of activity, speeds of reaction, but setting no goals and shaping no habits. Certainly they offer an incomplete and totally inadequate account of the person, and in no case are they a substitute for the labors of the social scientist.

CHAPTER V

THE PROBLEM OF DEVELOPMENT

The Instinct Controversy

Introduction.—For the past twenty years psychological literature has been full of many discussions and experiments centering around the problem of instinct and original nature. On the one hand, there have been those who feel that "instincts" and "original dispositions" form the principal basis for the differences between individuals, classes, races, and nations. These psychologists urge, moreover, that all our habits are formed "in the service of" our instinctive dispositions, and without this central core of purposive trends human behavior would be that of a reflex machine. In fact, they have termed the attempt to build up an account of behavior in terms of reflexes and their compounding a "muscle-twitch" psychology, emphasizing the contrast between the long-term chains of actions which are unified by an indwelling purpose and the momentary spasm of contraction of the typical spinal reflex. This group contains many mentalists, that is to say, those psychologists who are primarily interested in the facts of consciousness. Not only have their descriptions leaned rather heavily upon a hypothetical neurology, they have not always stopped to attempt a clear-cut physiological formulation of what an instinct really is. They have been more interested in describing the purposive aspect of human conduct than in making either a physiological or a mechanistic analysis. McDougall, in fact, is prepared to treat the issue as a moral problem, and warns the beginner in psychology, " . . . who hesitates at the brink of the slope that leads to materialism and a rigid determinism . . . [to] look down the slope; and there in imagination he may see the sturdy figure of T. H. Huxley, struggling in vain in his old age to lay the spectre he had so confidently helped to create; there also he may descry the forlorn figure of Herbert Spencer, once acclaimed the king of mechanists, but now remembered as the author of a 'chromo-philosophy' of scandalous vagueness. Let him turn and look upward, and he will see the serene figures of

Charles Darwin and Newton and Faraday, of Herman Lotze, of Leibnitz and Plato and Wordsworth, and of all the great poets, an august company of great men who refused to 'lay the intellect to rest upon a pillow of obscure ideas,' whose voices still ring down the ages, insisting that Man is more than mechanism and may yet be master of his fate."[1]

But there is another group whose members are not afraid of the terms "materialism" and "mechanism" and who find nothing but a "pillow of obscure ideas" in the writings of the instinct psychologists. Indeed, they find the very term "instinct" unsatisfactory, for it has had a most varied set of usages. As Bernard's study of the literature shows, various authors have posited from one to more than a hundred different instinctive tendencies, and in the sources which he examined more than five thousand supposedly instinctive patterns were mentioned.[2] The psychoanalysts, as a rule, get on with a few; for example, the sex instinct, the ego instincts, the self-preservative instinct, and the death instinct. McDougall himself is sure of seven (flight, repulsion, curiosity, pugnacity, self-abasement, self-assertion, and the parental instinct); and believes that to these we should add reproduction, gregariousness, acquisition, construction, and the more general dispositions of imitation, suggestion, emulation, and play. Clearly, an instinct is much more like a functional classification of human behavior, a classification in terms of the ends served, rather than in terms of structures, mechanisms, or any of those biological traits which can be inherited (or, for that matter, counted). As anyone who has attempted such a classification can testify, the purposive aspects of human behavior are well-nigh endless. Shall we call the activity of the hunter a wandering instinct? Or is it food getting? Or self-preservation? Or curiosity? Or emulation? Or pugnacity? And if a single act has all these (and many more) aspects, shall we hope to exhaust the purposive description of behavior short of the limits of our vocabulary?

The "Anti-instinct" View.—The "anti-instinct" group is inclined to discard the concept altogether, and in the place of vaguely defined "psychophysical dispositions" (McDougall) turn to the simple stimulus-response units, the reflexes, which can be objectively investigated and physiologically defined. These simpler units,

[1] From McDougall, William. *Outline of psychology*, p. 29. New York: Scribner, 1923. Reprinted by permission of the publishers.

[2] Bernard, L. L. *Instinct*. New York: Holt, 1924.

they argue, are integrated under the stress of external stimuli, and it is to the environment that one must look for the explanation of the more complicated trends in behavior. The simultaneous and serial evocation of the part-activities links them into chains, and the experience of consummatory releases establishes the purposive anticipation of goals. We are not born with goals, nor ideas, nor purposes, nor tendencies, nor "psychophysical dispositions"; but rather, we are, in the first place, organisms, structures with reflex potentialities, and the shaping and directing of these into sharply defined patterns of intelligent action comes with experience in our environment.

This second group has been the aggressor, and throughout the past two decades has ceaselessly criticized the instinct psychology. There is no question but that the instinct psychology has contained many abuses. In one respect it represents one of the greatest weaknesses to which the scientific mind is liable, namely, the naming fallacy. Molière's physician who, when questioned as to the action of morphine, explained that its powers were due to a soporific tendency in the drug, might stand as the best symbol of this type of thinking; and perhaps the instinct psychology would make a close second. For when we explain the painstaking research of the scientist as due to curiosity, or of the bridge builder as due to a constructive instinct, or the solicitude and care of the mother as due to maternal instinct, or the shrewd calculations of the banker as due to a collecting (or hoarding, or "property") instinct, are we not, like Molière's physician, just playing with words and naming the activities instead of seeking their explanation?

And beyond the logical weaknesses of the instinct psychology there were human and social reasons for attacking it. From the time of Aristotle, who had explained and justified the stratification of Grecian society (as due to the fact that some men are *by nature* slaves), to McDougall,[1] who explained and justified the dominance of the Britishers in India in terms of a superior mental and moral endowment (for which he offers scant evidence), an instinct psychology has served to defend conservativism, entrenched interests, and to block the progress of reform. For example, one who was interested in a more humane and intelligent method of treating, and possibly rehabilitating the criminal, was confronted with the

[1] Cf. McDougall, William. *Is America safe for democracy?* New York: Scribner, 1921.

statement that "criminals are born, and not made." To be sure, the conservatives were never united. One appealed vaguely to criminal tendencies, another spoke of the criminal as emotionally feeble-minded, Goddard attempted to convince us that the problems of delinquency and crime were almost entirely matters of failure of native intelligence, and still others insisted that the eradication of crime demanded glandular therapy. But on one point they were united, namely, that criminality was not a matter of training, of environment (that is, they were agreed that it was *not* a disease of society but rather of the individual); it was an affair of bodily constitution, inherited nature, or of instinctive tendencies. Similarly, if one advocated socialism, he was confronted with the statement, "You can't change human nature," and there would be vague references to an acquisitive instinct, or an instinct of property, or to various supposed traits of the American people, or to class differences in intellectual and moral traits which precluded a classless society, etc. Or, if one advocated the abolition of war he was discouraged by the observation that there was an instinct of pugnacity, and that so long as the adrenal-sympathetic mechanism continued to function as it did, within individual organisms, one might be prepared to see men and nations fight when thwarted. Nothing short of a change in the biological nature of man could bring about the pacifist's utopia.

The transparency and logical weakness in these defenses of the established order did not prevent the reformers from positing similar hypothetical innate traits. Kropotkin could insist that gregariousness was the fundamental trait of the higher animals, and that cooperation, mutual trust, and good will were natural traits of man, and that "man's inhumanity to man" sprang from a social organization which fostered bad habits.[1] Against the instincts proposed by the orthodox economist Veblen advanced the "instinct of workmanship," a grouping of tendencies offended "by waste of substance or effort" and gratified by the "efficient use of the means at hand and adequate management of the resources available for the purposes of life . . . "[2] Against the criminal instinct, the prison reformer posited an instinct of "loyalty," and planned a type of

[1] Kropotkin, P. *Mutual aid. A factor of evolution.* London: Heinemann, 1904.

[2] Veblen, Thorstein. *Instinct of workmanship*, pp. 31–32. New York: Viking, 1918.

self-government in the prison to the end that the loyalty which is first confined to the gang might be extended to a broader social group, and the prisoner fitted to return to society, trained in the ways of citizenship.[1]

These observations should make us all skeptical of every use of the term "instinct," for obviously the apologists for the old and the new order of things are merely appealing to a hypothetical set of mainsprings. In their eagerness to promote or justify some institution or way of life they have sought, as an ultimate sanction, some innate biological propensity. There seems to be no better apology for an institution than to show that it conforms to man's instinctive endowment and no greater condemnation than to indicate that it is "against human nature." But when hypotheses can be fitted to diametrically opposed counsel, it is time for a fresh examination of the hypotheses. Otherwise psychology will continue to be what so much of social science has been: a rationalization of social arrangements and a scientific cloak for one's pet prejudices.

The Nature of "Original Nature"

Structure and Behavior.—If there are definite original trends, capacities, instincts, they must spring from inherited bodily structure. Upon that most psychologists will agree, for by now the science has no place for disembodied mental forces. The actions of living organisms represent the functioning of physical structures and the only mechanism of transmitting mental traits from one generation to another, apart from the continuous operation of a shaping material environment and a social tradition, must be found in those structures which the geneticist studies, the gene and the chromosome. It is true that this platform of agreement gives cold comfort to those who depend upon purely spiritual entities; but if the concept of instinct is to be linked with the belief in the transcendental and suprasensible subject matter of some religions and philosophies, then it is already excluded from the domain of science, where matter-of-fact methods of observation and proof must hold.

The real question at issue is, Does the mechanism of biological inheritance provide the complicated, adaptive, and purposive trends which the concept of instinct implies? That it will set limits of attainment goes without saying. No amount of exposure to a

[1] Osborne, T. M. *Society and its prisons.* New Haven: Yale Univ. Press, 1916.

favorable environment, or to social tradition, can make the amoeba and paramecium into anything but simple, microscopic, one-celled animals. And protozoan behavior is not merely limited, each has quite individual modes of responding to the different stimuli of its environment. There is no reason why we should not be able to explain many of the peculiarities of each animal species in terms of the protoplasmic framework of which it is built. Just as we attribute the performance of a sailing vessel to its keel, its spread of sail, the distribution of weight, and the arrangement of its parts, so we should be prepared to explain the behavior of the pointer, the monkey, the child, in terms of an olfactory endowment, a particular musculature, or a level of development of the nervous system, or to similar physical factors.

Moreover, there are many highly specific acts, such as the simple reflexes, which we regularly explain in terms of structure, of sensori-neural-motor connections. Now, just as the knee jerk, the eyelid reflex, the contraction of the pupil to light, may be attributed to inherited connections in physical structure, it is argued that we may account for the nest building of birds, the homing of pigeons, mouse catching of cats, etc., by similar though more complex mechanisms. And if the logic applies through the lower portion of the animal scale, why should it not be extended to man, and used to explain some of the major trends in human behavior and the persistence of many human institutions? Thus, it has been applied to human sex relations and to the institution of the family. Instinct has been invoked to explain our perception of space and the development of locomotion, eye-hand coordinations. The fact that Bernard found more than five thousand instincts listed in the various psychological treatises he examined indicates, in fact, that the logic has been applied to almost every phase of human behavior.

The Search for Adequate Criteria.—It is the extension of the logic to the higher forms and to the more complex trends that arouses objections; for at precisely these points it is difficult to secure the objective evidence, comparable to that obtained in the study of the simple reflexes. The neural threads which mediate the impulses controlling the eyelid reflex have been mapped with fair accuracy; but there is no comparable mechanism for the nest building and homing of birds. And although the geneticist may feel confident that he has located unit characters for the various physical attributes of Drosophila, there is no similar evidence for the long-term trends

of human behavior, or for such patterned reactions as space perception, locomotion, etc. On the contrary, there is clear evidence that other controls are at work in many cases, and that what had previously been treated as the product of inherited structure was in fact the outgrowth of training.

Clearly, our approach to the question cannot be dogmatic. There is every reason to believe that inherited mechanisms exist, and there is no logical reason for limiting them to the simple reflexes. Our question should be, To what extent do experimental facts justify an explanation of behavior in terms of such mechanisms? And where completely satisfactory evidence is lacking, what criteria shall we apply to the behavior we observe if our views are to achieve any persuasive power? Since in almost every case subject to dispute there will be no isolated gene, no carefully mapped sensorimotor pathway, what tests will prove convincing? Perhaps if we can show that the pattern appears without tuition, and that its sole condition seems to be the maturing of those structures common to the species and supposedly gene-determined, in short, that growth and not experience determines the integration, we shall have made a case for instinct. For practically when we call an act instinctive we mean that it is as inevitable as growing up, that nothing need be done to establish it.

We cannot say that the term is equivalent to "actions present at birth" for the obvious reason that the organism is not mature at this time. Neither the nervous system, nor the sense organs, nor the muscles and bones have reached their full development. The physical changes which take place at adolescence should be enough to remind us of this fact. Nor is it at all certain, on the other hand, that prenatal habits have not been established. The rhythm of waking and sleeping, to take one possible example, may have some relation to prenatal conditions. Others have suggested that the grasping reflex may be due to prenatal conditioning, arguing that any condition producing the contractions would have to be accompanied by tactual stimulation of the palm, since the child's own fingers are curled against it in these prenatal days. Such a pairing of stimulation, it is argued,[1] would result in a conditioned response to touch upon the palm. Now, while this is sheer speculation it does represent a very live theoretical possibility, namely, that many

[1] Holt, E. B. *Animal drive and the learning process*, p. 38. New York: Holt, 1931.

of the reactions present at birth are the outcome of a definite type of conditioning.

Neither should we insist upon limiting our "original" endowment to those activities in whose development the environment has played no part whatever. The work upon the growth of neural structures indicates that the neurofibrils take a course which is determined in part at least by the stimulating field.[1] In setting up a criterion for instinct we should take care not to demand the impossible. We cannot describe our instinctive action as one to which the environment has made no contribution whatsoever, for the simple reason that there are no such activities. The environment was present at the first cell division, and until we carry on the development process *in vitro*, controlling all the chemical, thermal, gravitational, and other factors, we shall not know to what extent a more or less constant maternal environment has contributed to both the shape and the form of the organism, and to its reaction potentialities. And as a source of nourishment, the environment must be an ever-present factor in the growth process. Heredity and environment are in one sense like two factors which when multiplied yield a product; let either factor fall to zero, and the product is zero. The organism is thus the *product*, and not the *sum* of nature and nurture. We shall not ask the instinct psychologist to produce an activity in which the environment shall have played no part whatsoever.

The Habit Factor in the "Homing" of Insects.—What we shall have to ask is that every precaution be taken to exclude all possibility of learning. When this is properly carried out, many acts which we call instinctive are seen as the outcome of specific training. For example, it was customary at one time to speak of the remarkable sense of orientation of the ant and the bee as due to a homing instinct. Both go out on long forays for food and return directly to the nest or hive in such an altogether remarkable manner that it was easy to ascribe the pattern to a "homing" instinct, although this solved no problem and introduced new ones. Turner, however, in the case of the ant, was able to show how such a pattern developed.[2] Mount-

[1] For a discussion of the views of Kappers and others on this question see: Coghill, G. E. *Anatomy and the problem of behavior.* New York: Macmillan, 1929; Child, C. M. *Physiological foundations of behavior.* New York: Holt, 1924.

[2] Turner, C. H. The homing of ants. An experimental study of ant behavior. *Jr. comp. Neurol.*, 1907, 17, 367–437.

ing an artificial nest and food source upon an observation table, he watched the ants make their first blundering forays. Back and forth in completely irregular fashion they proceeded, until one chanced to stumble upon the food. And then a different and equally random course was followed back to the nest. But with repeated trips the path became shorter, false turns and loops were eliminated, and a more or less direct line of communication established. Turner speaks of a few individuals who, returning loaded with food, were unable to recoil quickly enough when they reached the edge of a platform on which the food was placed. These individuals who fell to the surface of the table below came to prefer this return route, and used it regularly. Others who delayed too long on the return, and seemed lost, were offered the experimenter's spatula, and as this was repeated the behavior of these few individuals suggested that they came to expect the "elevator" which restored them to the nest level. Clearly we are not dealing with instinctive homing activities; but rather with mazelike orientation patterns built up by a trial-and-error process of exploration and the gradual elimination of false starts and turns. Similarly, observers have noted that young bees, when first emerging from the hive, circle about the hive in ever-widening arcs, and only gradually come to make the long and direct flight to the food supply and return. And in the case of both bee and ant it can be shown that the habits are built up in response to very specific stimulus configurations, configurations which could not by any stretch of the imagination be prefigured in the germinal endowment of the individual; and breakdowns or reversals in these habit systems can be induced by changes in such configurations. Apparently we need seek no mysterious inherited "compass sense," which is to guide the bee and the ant. And if our knowledge of the migrations of birds and of the homing pigeon is scantier, is there any reason for assuming an instinct to be operative in these latter cases—other than the fact that the precise observations are lacking?

Instincts as "Activities of Unknown Origin."—All this suggests that an instinct is likely to be invoked where our ignorance is greatest, and in addition to its being an altogether unsatisfactory substitute for an explanation, in such cases, it may serve to stop further inquiry or to delay specific attempts at tuition where the latter is needed. Consider the effect of assuming that musical ability in the human child is an inherited, or instinctive, affair.

So long as talent, like murder, is viewed as a thing which *will* out, nothing need be done about it. If a child happens to have it, that is his good fortune. If not, that is too bad, but our responsibility as parents and educators is discharged when we take care of the fortunate ones, and give further training to those who are able to show the beginnings of talent. As for *producing* the talent, we assume no responsibility whatever, shifting that burden to blind nature. Is it not possible that if ants and bees have to learn to find their way by habit, through a visual environment, a child may likewise discover the values of an auditory world by a similar learning process?

It is this all-too-frequent absence of experimental controls which tempts one to describe an instinct as an "activity of unknown origin." The practical application of our "unlearned" criterion results in a collection of instances of behavior whose history is quite obscure. When we know the origin of an act, step by step, and have control of the circumstances necessary to produce it, then we do not need our concept of instinct. It is unquestionably because behavior, both animal and human, is so full of examples which have so far defied analysis that our instinct category has remained so large.

The Behavior of Sphex.—Consider, for example, the solitary wasp. As told by Wheeler:

The female Sphex, after mating, digs in sandy soil a slanting or perpendicular tunnel and widens its end to form an elliptical chamber. She may thereupon close the entrance, rise into the air and fly in undulating spirals over the burrow, thus making what is called a "flight of orientation," or "locality study," because it enables her to fix in her sensorium the precise position of the burrow in relation to the surrounding objects, so that she may find the spot again. Then she flies off in search of her prey, which is a particular species of hairless caterpillar. When it is found, she stings it into insensibility, malaxates its neck, while imbibing the exuding juices, and drags it or flies with it to the entrance of her burrow. Here she drops her victim and, after entering and inspecting the burrow, returns and takes it down into the chamber, glues her egg to its surface and closes the burrow by filling it with sand or detritus collected from the surrounding soil. As soon as the next egg matures in her ovaries she proceeds to repeat the same behavior cycle at some other spot. In the meantime the provisioned egg hatches, and the larva, after devouring the helpless caterpillar, spins a cocoon, pupates *in situ* and eventually emerges as a perfect Sphex.

Some of our species of Sphex actually tamp down the filling of their burrows with a small, carefully selected pebble, held in the mandibles and

used as a hammer or pestle. This astonishing behavior which has been carefully observed by no less than nine investigators . . . can hardly be reduced to simple physiological reflexes. The same would seem to be true of the orientation flight and return to the burrow and the fact that some species of Sphex provide the egg with a single large caterpillar, others with several small caterpillars, but in all cases with just enough food to enable the larva to grow to the full stature of a normal individual of its species. The question also arises as to the proper interpretation of the peculiar predilection of the wasp for a particular species of prey.[1]

Truly there is enough of the remarkable here. So much so that it is easy for the attitude of wonder to overcome proper scientific skepticism. Thus Fabre was led to describe the wasp as a "clairvoyant surgeon" and believed that her sting was guided exactly to the nerve centers, by instinct, whereas more exact observation showed that "the stinging of the prey follows reflexly as soon as it has been seized and comes in contact with the wasp's sternum, and that the accidental position of the prey when it thus releases the reflex determines the point where it will be stung."[2] Wheeler has suggested that much of the mystery attached to this behavior cycle comes from the way in which the account violates the natural time order of events. Instead of beginning with the infant Sphex, sealed up in her dark chamber with nothing to eat but caterpillar meat, the proper historical (and dramatic) order is reversed. Wheeler speculates upon the consequences of this restricted diet for later food choices, and upon the experience obtained in digging her way out of the chamber for later nest-digging skills. Wheeler's speculations are reinforced by the work of Sladden, on the stick insect. This insect, normally induced to feed upon ivy with difficulty, was led to turn from its "natural" privet, in a measurable degree, simply by feeding the first generation entirely upon ivy. Whether it is a matter of change in body chemistry or, as Wheeler suggests, a matter of early experience, it is clear that an experimental answer is demanded for this and similar questions, rather than the wonder-inspired attitude of awe at nature's mysteries, or the wisdom of Providence, which characterized so much of Fabre's account.

[1] Wheeler, W. M. *Social life among the insects*, pp. 53–55. New York: Harcourt, 1923. Reprinted by permission of the publishers.

[2] *Ibid.*, p. 50. New York: Harcourt, 1923. Reprinted by permission of the publishers. Wheeler bases this statement upon the work of Roubaud and Rabaud.

Until such experimental answers are accumulated we shall have to call the use of the instinct hypothesis to explain the marvels of insect life an "interpretation" and remember that the interpretation is founded upon rough analogies and not upon certain evidence.

The Concept of Maturation. Developmental Schedules

Every species has its developmental schedule. That is to say there are certain common patterns which appear in a more or less definite sequence at (again more or less) specific stages in the life span. It is true that the timing of their appearance does not follow the accuracy of a clock. There is considerable dispersion, and in some cases variability in both patterns and sequence. In general the simpler animals, especially those which show little capacity for learning, will follow the more fixed schedules. We can count on complete locomotion mechanisms in the guinea pig, at birth, and the date of sexual maturity and the emergence of copulatory behavior can be predicted in a given species of rats within a narrow range. On the other hand, we merely know that the human child will walk somewhere between the ninth and sixteenth months, as a rule, but we cannot name with any great exactitude the creeping, crawling, hitching, standing, walking, running cycle the individual will follow. And as for the human being's heterosexual adjustment (and many do not achieve this at all), neither its pattern nor its timing is too closely fixed by any biological clock. The physiological changes which constitute adolescence will have a greater definiteness than the behavior adjustments which give expression to these, and it is apparent that when these patterns of expression do appear the process of habit formation has had a great deal to do with them.

The Attempt to Separate the Factors of Growth and Habit Formation.—In order to separate the factors of physiological growth and habit formation (and the instinct hypothesis views the former as the gene-determined basis of instinct) some measure of control of the environment must be introduced. If the progressive integration of behavior patterns which constitutes development is the product of (*a*) an intrinsically determined maturation, or (*b*) of configurations of stimuli which condition the patterns, or (*c*) of a mixture of the two, then a control over the environmental conditions offers the most plausible way of unraveling the factors in any given case.

Thus Carmichael, studying the swimming movements of frog and salamander tadpoles,[1] experimentally removed the developing embryos from any possible effects of training by immersing them in a chloretone solution of an intensity just great enough to inhibit all movement. The experimental animals failed to respond to tactile stimulation when under the anesthetic, and remained immobilized until removed, washed, and restored to a tap-water environment. When a control group, allowed to develop in tap water, had been swimming for a five-day period, the anesthetized group was tested. At the end of a thirty-minute period,[2] during which the effect of the anesthetic wore off, the tadpoles swam in a way which could not be distinguished from their controls. It would appear that the locomotion patterns in the tadpole are not acquired as habits, and that the first incomplete responses are not to be viewed as the early stages of a habit, acquired by trial and error, but as the expression of immature physiological mechanisms which will complete themselves in accordance with a developmental schedule that is not dependent upon practice or upon patterns of stimulation from an outside environment.

Anatomical Changes Correlated with Developmental Stages.—We have already commented (Chap. II) on Coghill's study of Amblystoma. Here the developmental schedule was neatly correlated with neurological changes. The stages in development he described as follows:

(1) The nonmotile stage, in which the muscles can be excited to contraction by direct stimulation, as by the stab of a sharp needle, by mechanical impact, or by electricity, but cannot be excited by light touch on the skin;

(2) the early flexure stage, when the animal first responds to light touch on the skin;

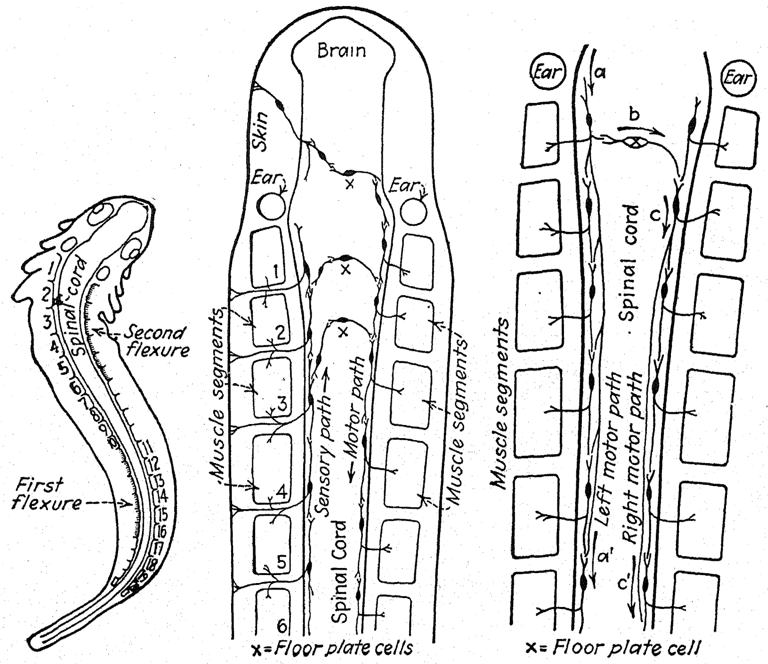
(3) the coil stage, marked by the bending into a tight coil;

(4) the "S" reaction, which is characterized by the reversal of a flexure before it is completely executed as a coil; and

[1] Carmichael, L. The development of behavior in vertebrates experimentally removed from the influence of external stimulation. *Psychol. Rev.*, 1926, 33, 51–58.

Carmichael, L. A further study of the development of behavior in vertebrates experimentally removed from the influence external stimulation. *Psychol. Rev.*, 1927, 34, 34–47.

[2] Experimentally determined by reanesthetizing some of the swimming controls.



A B C

FIG. 47.—*A*. The S reaction in Amblystoma. Diagram showing swimming movement in which the first flexure has passed tailward and the second flexure is beginning at the forward end.

B. The coil reaction mechanism. The floor-plate cell (x) has now developed so that a stimulus applied to the skin in front of the ear is relayed to the motor tract of the opposite side. Since at this stage these commissural cells are developed at the anterior end only, a stimulus on any point of the body must enter the neuromotor mechanism at the anterior end and spread thence tailward. Note the sensory chain on the left half of the figure.

C. The swimming mechanism. Sensory system omitted; arrows indicate direction of conduction. As the initial impulse (a) passes tailward (a'), it excites a wave of contraction. At this stage, the motor neurons have developed collaterals which join the commissural cells (x) of the floor plate, and it is these collaterals which provide the essential mechanism for the swimming stage. Coghill believes that they carry excitatory impulses to the muscles of the opposite side, and since they cross additional synapses, the retarded arrival of these impulses produces flexures of the opposite side which follow those on the first. Thus the parallel but alternating waves are accounted for. *(From G. E. Coghill. Anatomy and the problem of behavior, pp.* 8, 12, 16 respectively. *New York: Macmillan,* 1929. *By permission of the publishers.)*

(5) the performance of the "S" reaction in series sufficient to effect locomotion.[1]

[1] From Coghill, G. E. *Anatomy and the problem of behavior.* By permission of The Macmillan Company, publishers.

When Coghill was able to show that in the nonmotile stage there was no neural bridge between sensory and motor structures, and that flexure began when "floor-plate cells" lying in the brain stem and upper cord first appeared, we begin to apprehend the type of maturation indicated in the work of Carmichael. The flexure began at the head because this was the first place where cross connections were established, and it deepened into the coil as the motor chain was completed. Similarly:

> At the time swimming begins there is a growth of collaterals from fibers of the anterior part of the motor tract into relation with the dendrites of floor-plate cells. These collaterals cause an excitation that is on its way to the muscles of one side to be carried through the commissural cells of the floor-plate to the motor system of the other side. But in this passage to the muscles of the opposite side more synapses are involved than there are in the path to the muscles of the same side; so that the second flexure follows the first by a very brief interval. In the same manner as the impulse for the first flexure excited the second flexure, so the impulse for the second excites the third, and so on.[1]

We may conclude, therefore, in Coghill's words, "The behavior pattern develops in a regular order of sequence of movements which is consistent with the order of development of the nervous system and its parts," and when we couple this finding with that of Carmichael, add that the order of development of the nervous system is not determined by practice, or by any known pattern of external stimulation, and is more properly viewed as an affair of physiological maturation, or growth.

Myelinization and Maturation.—Another line of neurological investigation is illustrated by the work of Langworthy on fetal kittens and on pouch-young opossum. The latter offer an unusually convenient type of subject for the study of early development, for the early weeks of postnatal development of the opossum correspond to the intra-uterine period of other mammals, such as the kitten. In the case of the kitten, Caesarean sections must be employed, together with considerable care in the handling of the subjects. Langworthy was able to establish rather definite developmental schedules for both animals, but no attempt was made to parcel out the maturational components through control of the environment. Rather, this investigator sought neurological evidence, and through histological studies of the developing nervous structures attempted

[1] From Coghill, G. E. *Anatomy and the problem of behavior.* By permission of The Macmillan Company, publishers.

to establish correlations between neural and behavioral events. He found, for example, that just as the development in behavior progressed from head to tail so the myelinization of nervous structures proceeded cephalocaudally. When the forelimbs of the kitten were beating alternately, as in normal progression, the hind limbs were able to make a massive, explosive contraction only. At this time the myelin sheaths of the nerve fibers had been completed in the forequarters only. When the normal crossed-reflex alternations of the mature walking pattern emerged, the myelinization had extended backward along the cord to the level of the hind limbs. Tactual, visual, auditory, gustatory, vestibular, and other responses conformed to the myelinization schedule closely enough to enable the experimenter to write: "From the previous description it appears that it is theoretically possible to correlate the behavior of the fetal and young kittens with medullation of fibers in the spinal cord on the assumption that pathways in the nervous system become myelinated at the same time they become functional."[1]

The correlations obtained in the study of the opossum were not so close as those obtained in the kitten, and many paths were clearly functional without the insulating sheaths. Langworthy writes, however, that: "The precocious activity of the young opossums mediated along nonmedullated pathways suggests an exception to the main thesis, but by no means invalidates it. Examples cited in this report indicate strongly that pathways in the nervous system become myelinated at the time when they become functional."[2]

The notion that the myelin sheath has an insulating function and that sharply defined patterns of stimulation cannot be carried over a nerve trunk until such sheaths are laid down has certain attractive features. On the basis of an analogy of a cable of electric conductors we could understand how definite "circuits" could not portray all their possible patterns until the insulating process had completed itself, and we could understand both the order of development (*e.g.*, from head to tail) and the process of individuation by which the gross and explosive twitches of the hind limbs became the

[1] Langworthy, O. R. A correlation study of the development of reflex activity in fetal and young kittens and the myelinization of tracts in the nervous system. *Carnegie Inst. Contr. Embryol.*, 1929, 20, No. 114, 127. Reprinted by permission of the Carnegie Institution, publishers.

[2] Langworthy, O. R. The behavior of pouch-young opossums correlated with the myelinization of tracts in the nervous system. *J. comp. Neurol.*, 1928, 46, 201–248. Reprinted by permission of the Wistar Institute, publishers.

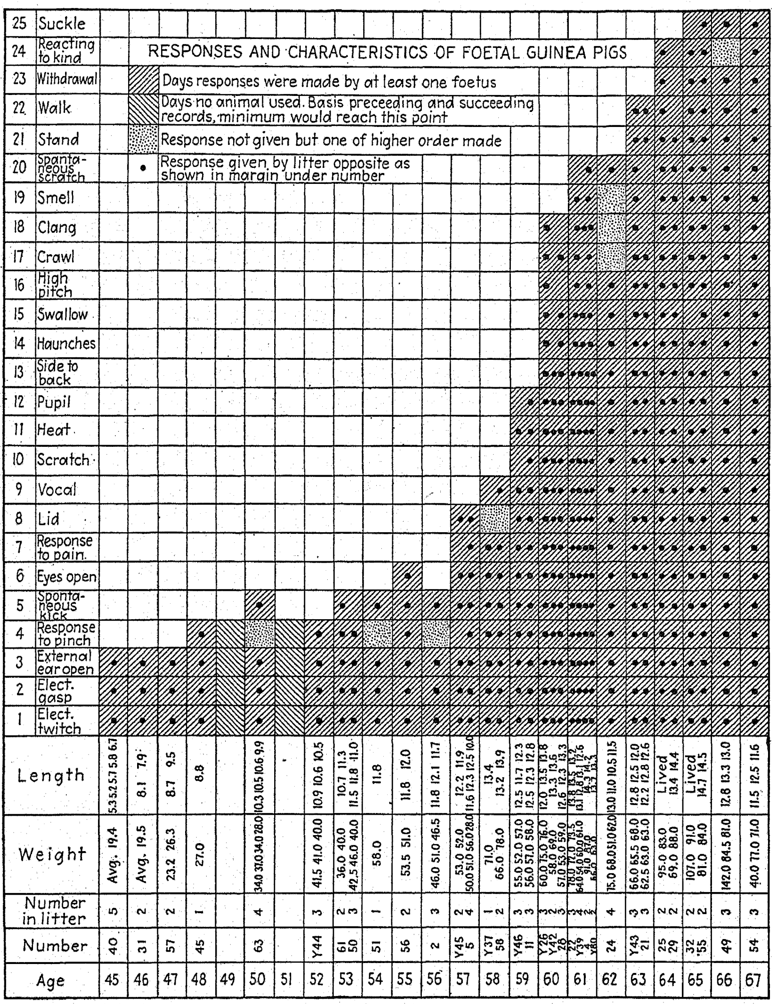


FIG. 48.—Developmental schedule of responses in fetal guinea pigs. The chart shows that all 25 of Avery's developmental tests were "passed" by the fetal guinea pigs before the full gestation period had been completed. From the 63d day his subjects could stand and walk. Age indicates the length of gestation period; No. indicates mothers' numerical designation (*Y*, young mother). The responses and characteristics given in the column at the left are numbered from bottom to top in their order of appearance. (*From G. T. Avery. Responses of foetal guinea pigs prematurely delivered. Genet. Psychol. Monogr.*, 1928, 3, 301. *By permission of the publishers.*)

accurately timed patterns of reciprocal inhibition, alternating contractions, etc. We could also understand the process whereby maturational, or growth, factors could extend the process of development beyond the level where the nerve cells have been completed and the fibers have penetrated all the tissues. In fact, since the human cerebral cortex does not receive all of its myelin sheathing until the third decade, we should have laid the basis of a progressive unfolding of capacities well into mature life. The work of Langworthy may be said to have made some such speculation reasonable, but it by no means renders it conclusive. The existence of much coordinated behavior before the myelin sheaths are present suggests that the myelin sheath is an accessory to some more basic developmental process.

A Study of Prenatal Development.—Another study may be mentioned as typifying a developmental schedule in a lower animal. Avery[1] studied the behavior of fetal guinea pigs, delivered by Caesarean section from the mother at definite intervals from the time of conception. Test stimuli to which the normally delivered guinea pig reacts on the 68th day after conception were applied to all fetuses delivered after the 45th day. Even at this earliest interval the premature animal began to react, responding with a gasp to a mild electrical stimulus, and between the 57th and 65th days there was a rapid increase in its behavioral equipment, including such responses as regular breathing, kicking to pinpricks, standing and walking, vocalizing in response to sound, and reactions to kind, suckling, etc. (see Fig. 48). Incidental observations showed that reactions of extremely complex character were fully matured before the point in the life cycle at which birth normally occurs. For example, when the 64-day-old fetus was removed from its litter mates or from a foster mother, and placed at one side of the observation table, it voiced its distress and attempted to return. One subject showed the ability not only to stand, walk, and run, but both climbed over and avoided obstacles, a highly complex coordination for which no prenatal experience could provide anything approximating training.[2] Avery sought to discover, also, any

[1] Avery, G. T. Responses of foetal guinea pigs prematurely delivered. *Genet. Psychol. Monogr.*, 1928, 3, 247–331.

[2] Similar evidence of a maturational factor in space perception was obtained by Lashley and Russell (1934), who reared rats in darkness and then compared them with normal controls in their ability to regulate a jump with reference to the

evidence of gravity reactions before birth, taking radiographs of the mother who was shifted at 5-minute intervals, for a 30-minute period. He found that the young kept their position in the uterine tubes throughout the series of positions, in spite of the fact that when they were removed from their mother within the hour they were able to roll to their feet as delivered, and returned to the upright posture as soon as placed on their sides or back.

Although the typical study of developmental schedules does not secure the neurological evidence such as found by Coghill, nor the proof that environmental conditions are not contributory (through the experimental alteration and control of the stimulating conditions), the type of evidence secured by Avery argues strongly for a maturational factor. Although given no previous opportunity to exercise such response patterns, the animals could stand, right themselves, run, avoid visual obstacles, and approach litter mates. It would thus appear that the growth process unsupported by practice is able to produce reactions of a high degree of complexity, reactions that are neatly adapted to their surroundings and the organism's needs. Thus, one of the questions raised by the instinct controversy has received an experimental answer.

The Experimental Study of Sexual Behavior in Rodents.—Nearly all the lists of instincts include, in one form or another, some mention of sexual behavior, and there is no dearth of descriptive material dealing with the reproductive activities of animals. Two studies by Stone[1] may serve to illustrate how the experimental control of the environment may serve to clarify the problem of the development of such behavior. Segregating males and females at weaning time (21 to 25 days old), he then introduced males to the females at intervals and observed their behavior. The complete copulatory

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distance of a near-by food platform. The experimenters found that longer distances caused the rats to use more force, and that the accuracy of adjustment was nearly equal for the two groups. These facts clearly lend themselves to the maturation explanation of the highly complex visual-motor coordinations involved in such spatial adjustments.

Lashley, K. S., and Russell, J. T. The mechanism of vision. XI. A preliminary test of innate organization. *J. genet. Psychol.*, 1934, 45, 136–144.

[1] Stone, C. P. The congenital sexual behavior of the young male albino rat. *J. comp. Psychol.*, 1912, 2, 95–153.

Stone, C. P. The initial copulatory response of female rats reared in isolation from the age of twenty days to the age of puberty. *J. comp. Psychol.*, 1926, 6, 73–83.

activity appeared usually between the 75th and 85th days, and because its initial performance appeared so suddenly and with such completeness (and because at all other than the observational periods segregation was continued) he regarded the pattern as the product of maturation. The pattern observed in the young novice closely resembled that of an experienced adult male. Similar results hold for the female's response. But one of 20 females observed under similar segregation failed during her first test period, and subsequently on a second test ten days later responded within 10 sec. Typically the complete response appeared after two or three attempted mountings of the male, but in some cases the initial performance was complete. It is worth noting that, in the case of the females studied, opportunity for playful rehearsal of anything approximating the complete sexual response had been reduced to a minimum by their isolation prior to the tests, which were made at maturity. In spite of this experimental removal of the experience factor, the activity under observation appeared at a definite stage in the life cycle, suddenly in some cases with no blundering whatever and in all cases with a minimum of that random behavior which one would expect if the pattern were learned.

Additional facts support Stone's conclusion that "the action systems displayed in this native heterosexual response are integrated primarily by endogenous factors which control sexual maturation." For example, there are the observations of Crew,[1] who found that, while albino and colored rats show a distribution of ages at puberty in which there was some overlapping, the difference in the averages of 39 (albino) and 52 (colored) days was found to be statistically significant. Thus, where temperature, population density, food, and care were equated, genetic factors produced different developmental schedules. Even more striking is Stone's breeding experiment in which he isolated, from a common albino strain, two groups of males and females, one of early and one of late puberty. In the F_6 generation the average age at puberty for the early group was 42 days; for the late group 58 days.[2]

Endocrine Factors in Development.—An additional internal control of the development process, revealed by the experimental

[1] Crew, F. A. Puberty and maturity. *Proc. 2nd Int. Cong. Sex Res.*, 1931, 1–19.

[2] Reported in the *Handbook of experimental psychology*, p. 366. Ed. by C. Murchison. Worcester: Clark Univ. Press, 1934.

study of the endocrines, also supports the maturation interpretation. Just as the administration of thyroid substance can induce very young tadpoles to change into frogs, so subcutaneous injections of pituitary substance can produce puberty praecox in young rats or mice. Beginning at the 15th day and following with daily injections, the transformation follows within a week.[1] The effect of castration on the one-day old female chick, resulting in crowing, strutting, and cocklike fighting, as well as the disappearance of the typical sexual behavior in the male castrate, all support the notion that if genetic factors are primary in the regulation of developmental schedules they may operate through the endocrines, the latter supplying the chemical substances immediately responsible for many of the dramatic metabolic (and behavioral) changes in the life cycle.

Maternal Behavior: an Illustration of the Complexity of the Problem.—An indication of the complexity of the actions which may appear in the reproductive cycle is offered by the observations of the rat mother at the moment of birth of her young:

The first signs of labor were detected by the observer at 9:30. The female was then flattened out on her abdomen with forelimbs extended and her hind limbs pressed against the wire mesh on the floor. The uterine and abdominal contractions persisted for about eight minutes. Then the female sat up on her hind limbs and vigorously licked the vulva. The first fetus was expelled by head presentation at 9:41. Immediately she took the young animal in her forepaws and removed and devoured the fetal membranes. The removal of the fetal membranes, part of which appears as a thin, glistening sheet surrounding the fetus, is accomplished so quickly that an unexperienced observer is apt to miss the act entirely and see only the severing of the umbilical cord. The latter was severed by biting it off close to the body of the young animal. Licking the young as the female rotated it in her forepaws continued for several seconds and she gave no attention to the remainder of the cord though it still extended from the vaginal orifice. Expulsion of the placenta, preceded by what appeared to be a single wave of peristalsis, quickly followed and the female dropped the young animal from her forepaws and took up the placenta which she began to consume at once. Five more young were delivered in quick succession; essentially, the female behaved in the same manner toward each fetus and the placenta as it was expelled. Animal five in this litter was delivered by breech, the others by head presentation. The first three animals in the litter were dropped at the front of the cage; then the

[1] Smith, P. E. The induction of precocious sexual maturity by pituitary homeo-transplants. *Amer. J. Physiol.*, 1927, 80, 114–125.

female changed her position and cast the next three at the back of the cage. At the end of the period of delivery three young were carried to her nest. This was accomplished by holding each one of the animals between her teeth. Animals one and three she grasped in middorsal region. Number two was picked up by its haunches. The mother then assumed a hovering position over the three young she had carried to her nest and allowed them to suckle. Forty-two minutes elapsed between the onset of labor and the first suckling of the young. . . . [1]

In this account of maternal activity there is no way of determining what is purely maturational and what is attributable to training; but it is clear that this particular assemblage is made for the first time, and that it occurs without hesitation. If we raise the question as to whether previous handling of food particles with the forepaws may have contributed to the skill, to take a single example, we merely suggest the difficulty which would attach to any attempt completely to parcel out the elements in an adult performance. In like manner, the copulatory activities studied by Stone must be composed of parts which have had previous exercise. The ordinary locomotion, spatial adjustments, reaction to nest mates, will figure (although the ability of the completely isolated animals to perform the act suggests that the social factors are of negligible importance). Thus, what we are inclined to attribute to maturation, and to the gene, may very well include environmental and training factors whose constancy enables us to neglect them in describing development. For practical purposes of prediction and control this neglect may cause no difficulty;[2] but for purposes of a complete theoretical account it leaves much to be desired. In any case, when we attribute the maternal or copulatory activities to maturation or to the genes or to the endocrines, and are unable to support and elaborate the way in which

[1] Sturman-Hulbe, Mary, and Stone, C. P. Maternal behavior in the albino rat. *J. comp. Psychol.*, 1929, 9, 203. Reprinted by permission of the Williams & Wilkins Company, publishers.

[2] Difficulty arises, however, as soon as the activity does not run true to form. When the rat mother not only devours the fetal membrane and placenta but her offspring as well, or when the human mother refuses to nurse her young and seems to lack all maternal interest and affection, we shall not be helped in our analysis and treatment of such aberrations if we are merely told that it is due to abnormalities in the maturation process or to a failure in the maternal instinct. Obviously we need to know more specifically where the developmental schedule was thrown off track, whether by endogenous or external factors, or the accidental configuration of integrating stimuli, or in the basic habits.

these factors operate, we have merely presented a problem, or at best located it. There is a temptation, in the face of the complexity of the problem and of the difficulty of unraveling the interwoven threads of causation, to fall back upon those convenient "psychophysical dispositions" of McDougall. If they were in good scientific standing, we could say that regardless of the origin of the part activities, be they reflexes, practiced habits, endocrine secretions, it is the instinctive disposition which assembles them at the appropriate time and assures the attainment of biological purposes. But a stimulus-response psychology has come to look either for a constellation of stimuli or for the completion of neuromuscular coordinations (through maturation or exercise) as the only legitimate explanation for emerging patterns; and until the developmental schedule can be completely phrased in these terms we cannot be said to have achieved a complete answer. The vaguely formulated disposition offers an easy, but specious, escape.

Exogenous Factors in Development

The Study of the Pecking Response in Chicks.—Other experimental studies clearly indicate that what might superficially pass for maturation, does indeed contain specific habit formation, and that so-called instinctive reactions, as well as developmental schedules, may not be explained in any wholesale fashon in terms of endogenous or intrinsic determiners. Consider the pecking reaction of the newly hatched chick, so important a part of food getting. The reaction can be elicited by a variety of visual stimuli, apparently, for an inkspot will do as well as a bit of food; and the discrimination between the edible and nonedible has to be learned. There is, moreover, a marked increase in the accuracy of the response, as development proceeds. Tested on the second day, the complete act of striking, seizing, and swallowing occurred but 10 times in 50 trials, and on the succeeding days accuracy rose to 28, 32, 37, 38, 38, and from the eighth to the twenty-fifth day accuracy fluctuated between 40 and 45 successes, apparently having reached its maximum.[1] Plotted on a curve, these figures show a very rapid increase at first, with a gradually diminishing rate of improvement until a plateau is reached. What causes the improvement? Is the chick like a marksman, perfecting its aim through practice, eliminat-

[1] Breed, F. S., and Shepard, J. F. Maturation and use in the development of an instinct. *J. Animal Behavior*, 1913, 3, 274–285.

ing false postural adjustments in a rather blind hit-and-miss procedure, or does this rapid improvement represent a rapid maturation of synaptic connections, a completion of sensorimotor arcs by the growth process? Our answer cannot come from an examination of the curve, for one can find cases of growth or of learning which show similar rates. Applying the isolational method, Breed and Shepard sought an experimental answer. They kept the chicks in the dark, and thus prevented all practice, and fed them with a medicine dropper. Then on succeeding days the chicks were removed from their dark quarters and tested. Once removed, they remained in the lighted cage and their subsequent development was studied. The initial performances of the delayed chicks were as follows:

Allowed to Peck for the First Time	Average Initial Score
3d day	5.5
4th day	3 1
5th day	8.7
6th day	2.0

Comparing these scores with those of the control group developing under normal conditions it is apparent that maturation alone cannot account for the improvement: instead of an initial accuracy of 2.0, the 6-day group should have scored 38. The experimenters noted, however, that the delayed groups speedily improved, and called attention to the fact that within a day or so the sixth-day group had caught up with the controls of the same age. One might interpret this as evidence of a *general maturation* which laid a more and more complete groundwork for the performance, so that the more mature chick required less practice for perfection. Such interpretations have been made[1] and have been used as a basis for a general view of development, but the present evidence is not sufficient to support the interpretation. To prove that the maturation is a *general* one, similar improvement in rate of habit formation would have to be shown in other skills, and to prove that the case is really representative would require a larger number of subjects than the experimenters used. This latter point was noted by Miss Moseley who discovered that the clearest case of improvement (the 6-day group) rested upon a single chick, and she undertook to repeat the Breed and Shepard experiment, using larger samples. Since the

[1] Cf. Allport, Floyd H. *Social psychology*, Chap. 3. Boston: Houghton, 1924.

control group consisted of 21 chicks, and the average figures represented the central tendency of a group made up of both fast and slow learners, no valid comparison is possible with but one subject.

Habits May Hinder Development.—Miss Moseley's repetition of the Breed and Shepard experiment confirmed the general curve of development previously established. She found, however, that the delayed groups did not show more rapid improvement; in fact, delay

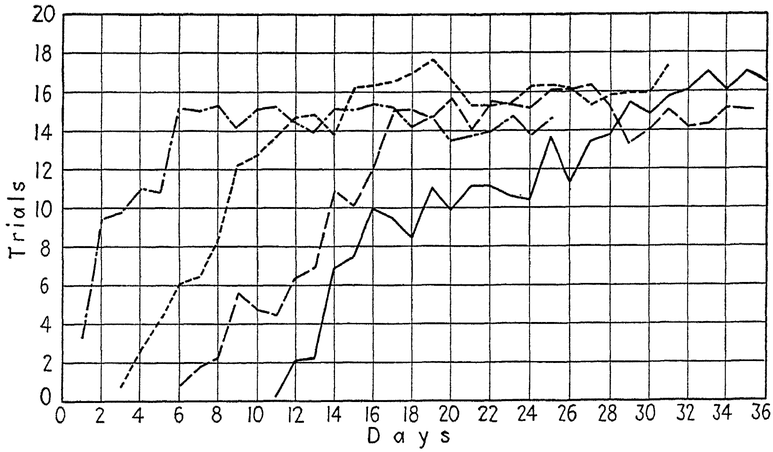

FIG 49.—Curves showing the development of the complete pecking response in normal and delayed chicks. The response recorded is the complete hit-seize-swallow. The age in days is represented on abscissas, and the number of successful responses on the ordinates. The improvement of the delayed chicks, although they are more mature at the beginning of their training, is seen to be a more gradual affair. The 11-day delay group does not catch up with the normals until 2 weeks of practice have passed. All the delayed chicks start with a low level of accuracy in the complete response. (*From Dorothy Moseley. The accuracy of the pecking response in chicks. Jour. comp. Psychol.* 1925, 5, 90. *By permission of the publishers.*)

interfered with the normal course of improvement. Miss Moseley not only used a larger number of chicks, but spaced her delays so that longer periods could be studied (3, 6, and 11 days.) On the sixth day she noted that the chicks undergoing testing gave the characteristic food "chirr" and ran to her hand instead of to the grains on the pecking board. They were apparently more excited by the hand which had regularly fed them than by the "normal" stimulus. Thus it appears that previously existing habits may interfere with the refinement of reflex coordinations, and the coordinations provided by maturation are attachable to a variety of cues. One is reminded of Spalding's observations on the chick, which will

follow any moving object, a duck, a human being, a box drawn on a string, and apparently with little preference in the matter. But this polymorphous character of the "instinctive" disposition disappears as soon as one pattern becomes fixated. Just as the child who has always had his egg extremely soft and "runny" will object to the hard-boiled variety, the hen-following chick scuttles out of sight at the approach of the moving man.

Training and Precision.—Subsequent observations by Bird[1] both support and modify the Moseley interpretations. Bird's study supports Moseley's findings in extending the delay to a period of 25 days, and in showing that with but 10 trials daily the chicks never approached normal accuracy. His findings modify those of Miss Moseley[2] in showing that during the first 48 hours (Breed and Shepard did not begin tests until the second day) there is an improvement which is maturational in character. Newly hatched, the chick shows the pecking reflex, but his wobbly posture and general muscular weakness do not permit accuracy; and apparently they do not permit such practice as would improve accuracy, for the customary controlled experiment shows that the improvement in the early hours is as great without practice as with it. In a later experiment Bird[3] found that as few as 25 trials involved in the measurement of the level of development produced an improvement in accuracy of the delayed chicks, whereas the same number of trials within the first 18 hours after hatching had no effect whatever. Bird is inclined to attribute an impairment in the ability of the delayed chicks (persisting to the end of the 20-day experiment) to nutritional factors, since it is associated with lower body weight. He thus opposes to the concept of interfering habits, suggested by Moseley, the suggestion that it is "Not the age at which normal feeding begins but a nutritive factor [which] appears responsible for the slight but consistently lower achievement of the delayed groups under consideration."[4]

[1] Bird, C. Relative importance of maturation and habit in the development of an instinct. *Ped. Sem. and J. genet. Psychol.*, 1925, 32, 68–91. Bird, C. The effect of maturation upon the pecking instinct of chicks. *Ped. Sem. and J genet. Psychol.*, 1926, 33, 212–233.

[2] Moseley, D. The accuracy of the pecking response in chicks. *J. comp Psychol.*, 1925, 5, 75–98.

[3] Bird, C. Maturation and practice; their effects upon the feeding responses of chicks. *J. comp. Psychol.*, 1933, 16, 343.

[4] Reprinted from *J. comp. Psychol.*, 1933, 16, 343, by permission of the Williams

Still another experiment, by Cruze, deals with the same problem. Five groups of chicks, of 25 each, delayed 24, 48, 72, 96, and 120 hr., and fed and watered in the dark in the interim—thus preventing normal practice as well as the formation of interfering reactions to visual cues of the type Moseley found—showed uniformly low initial accuracy. Some improvement in the "hitting" response seemed attributable to maturation, but the complete strike-seize-swallow cycle seemed to be a practice affair. Evidence for the existence of a general maturation effect, however, did appear; since the delayed groups improved more rapidly.[1]

Summary.—What is one to conclude from this half dozen studies of the pecking reaction? May we not say:

1. Visual-motor systems for which there is no basis in previous practice are possessed by the newly hatched chick. They involve coordinations of eye-neck-trunk-feet-legs and, as complex spatial adjustments, bear witness to the ability of the maturational process to produce intricate coordinations between organism and environment.

2. Beginning with a comparatively low accuracy (10 out of 50) the chicks improve rapidly at first, and then more gradually, until by the eighth day a rather high level is attained.

& Wilkins Company, publishers. Stone has also demonstrated the importance of the nutritional factor for the developmental schedule. Putting his rat-subjects on a restricted diet, barely sufficient for maintenance, he found that typical pubertal behavior was delayed on the average from 16 to 23 days, when the chronic inanition lasted for 20 days beginning on the 20th, 30th, and 45th days. He also found that the amount of the delay was greater when the stunting occurred earlier. Even more dramatic effects of nutrition are shown by the practice of beekeepers, who, following the practices of their insect workers, are able to "manufacture" queen bees by controlling the diet of the developing larvae. With ordinary food the insect eggs would become workers, but with a larger cell and a diet of "royal jelly" a queen with vastly different potentialities and proclivities is produced. Instead of nursing the young, building comb, visiting flowers, and filling the cells of the comb, etc., the queen becomes a veritable egg-laying machine, producing many times her own weight in eggs from the food that her worker nurses and grooms provide her. Here the very structure and pattern of behavior seem to flow from a nutritional source.

[1] An experiment by Padilla showed that chicks delayed for as long as 14 days were slow to peck. Only 3 of 21 pecked on the first day's test and the development of these was slower than normal. The remaining 18 were indifferent to grains and starved to death "in the midst of plenty." Padilla, Sinforoso G. Further studies on the delayed pecking of chicks. *J. comp. Psychol.*, 1935, 20. 412–443.

3. All experimenters have shown that, if the practice obtained in normal feeding is withheld, initial test accuracies are low, and two investigators have found evidence for a persistent, and possibly permanent, impairment (even of the capacity to acquire accurate responses). Such permanent impairment may arise either from the nutritional deficit involved in the experimental technique or from interfering habits set up in the early stages of development.

4. Three investigations show evidence of a general maturation. The evidence of Breed and Shepard, while itself founded upon insufficient evidence, is supported by the later study of Cruze, where larger numbers of chicks were involved. The elimination of the possibility of forming interfering visual habits in the latter case suggests that Moseley's results may have masked this same general maturation, the interfering habits being more powerful. The evidence of Bird suggests the nature of the general maturation process to be one of strengthening and perfecting a general posture (and practice may be involved here, though not pecking practice), and the results of this latter investigator show that it is within the early hours that the maturation effect is most noticeable.

The picture presented is of a roughly adequate reaction system which requires practice to perfect it. Environmental influences begin to operate from the start, and the events which lie between hatching and initial practice, of both a nutritional and a training character, alter the chick's "capacity" for future development; in some instances setting up preferences which will run counter to the patterns typical of the species. If a chick can be trained to follow a man instead of a mother hen, and to eat from the hand of an experimenter via medicine dropper rather than to seek its food by pecking upon the supporting surface, one is forced to wonder whether other "instinctive" dispositions are not equally polymorphous. Certainly the accurate and fully developed form of the pecking response cannot be attributed to purely endogenous or intrinsic controls.

Mouse-catching Behavior in Kittens.—The presence of habit factors within the maturation process is also revealed in the study of mouse catching by kittens. C. S. Berry[1] had early questioned the existence of an instinctive antipathy between the species. He wrote: "My experiments tend to show that this belief is not in

[1] Berry, C. S. An experimental study of imitation in cats. *J. comp. Neurol & Psychol.*, 1908, 18, 1–26.

harmony with the facts. When cats over five months old were taken into a room where mice were they did not show the least sign of excitement. A cat would even allow a mouse to perch upon its back without attempting to injure it, nor did the mouse show any fear of the cat. I have seen a mouse smell at the nose of a cat without showing any sign of fear."[1] This observation of Berry's prompted two investigators to study the development of the pattern. It seemed possible that Berry's cats might have possessed interfering habits or that the instinct to kill mice had somehow waned. Psychologists had been accustomed to speak of the waxing and waning of instincts, and had even stressed, as an educational maxim, the importance of "striking while the iron is hot."[2] That is to say, they thought of the developing human child as running through a series of instinctive levels (sometimes compared with the phylogenetic history of the race) and believed that when the instinctive disposition was at its peak the educator would find the child most malleable, his interests most powerful in motivating his studies, his learning capacity most efficient along the lines of the prevailing tendency. The two investigators who sought to check Berry's investigation noted that his animals were several months old. Perhaps as sedate, house-bred, and milk-fed animals they were like the human adult who has grown up without an induction into the world of the out-of-doors. Such an adult confronted with briers and barbed wire, wood smoke, sunburn, mosquitoes, the messy side of fishing, etc., usually "sees nothing in it" and wonders why otherwise intelligent adults waste such an amount of time and endure so many discomforts for the sake of such highly questionable objectives.

In view of the possibility, then, that (in Berry's animals) the instinct to kill mice had waned, or had never been evoked and fixated at the appropriate period, Yerkes and Bloomfield[3] determined to study development from the beginning. In order not to prejudice the matter, their animals were housed in a mouse-free room, fed on milk and beef (usually cooked) and fish. Such mice as they experienced were introduced at stated intervals for test purposes. During

[1] *Ibid.* Reprinted by permission of the Wistar Institute, publishers.

[2] Cf. James, William. *Principles of Psychology*, vol. II, pp. 401–402. New York: Holt, 1890.

[3] Yerkes, R. M., and Bloomfield, D. Do kittens instinctively kill mice? *Psychol. Bull.*, 1910, 7, 253–263.

their first week, when they were still sightless, they evinced no interest, and again, at 12 days of age, the test did not arouse them. At a little over a month, the third presentation did elicit some interest from one of the kittens, who growled and seized the mouse although she could not prevent its escaping. Even after the fifth exposure the more sluggish litter mates were uninterested, although all showed the pattern finally, pursuing, capturing, and devouring the mouse. Now while the fact that all their subjects developed the pattern, and that a rather definite period for its appearance may be assigned (somewhere between the fourth and eighth weeks), the evidence does little to support either the instinct or the maturation hypothesis, although it has been frequently offered as such. For there is no evidence that it is a mouse, as such, which is the stimulus. There were no controls in which odor, visual form, type of motion, etc., were introduced; and just as with the chick, which will follow child, hen, or box drawn on the string, it may be that we are dealing here with a general following coordination which would be elicited by moving paper or a companion's tail. Neither is the appearance of the activity sudden, dramatic, certain. On the contrary, for many trials the animals were indifferent, some kittens trembled with fear and made efforts to escape, and still others followed the moving stimulus with what might be called a mild interest. Obviously, too, the complete coordination involves many elements which must have figured elsewhere, and hence are subject to practice effects. And there is the further possibility that the accidental taste of blood, as the sharp teeth penetrated mouseskin, may have been the factor which altered subsequent anticipation. Perhaps it is only the previously tasted mouse which becomes an object to pursue-and-eat. Certainly there is no evidence which rules out these interpretations. Indeed, they are more than strongly suggested by the later work of Kuo.[1] Among other things he found that:

9 out of 20 kittens reared in isolation kill rats.

18 out of 21 kittens reared in a rat-killing environment (*i.e.*, with other cats who had established the pattern) killed rats at 4 months.

3 out of 18 kittens reared with rats as cage mates killed rats, and these did not attack their cage mates.

A Summary with Few Generalizations.—In the light of these facts, the developmental schedule of mouse- and rat-killing activities

[1] Kuo, Z. Y. The genesis of the cat's responses to the rat. *J. comp. Psychol.*, 1930, 11, 1–35.

in kittens does not appear to be one of those cycles "integrated primarily by endogenous factors." The type of nest mate, previously acquired habits, the habits of nest mates, all seem to alter the schedule. The divergence between the results of, say, Carmichael or Stone and the results of Kuo should warn us against trying to frame any general view of the developmental process on the basis of a limited group of studies. Nor can we frame a theory for the development of a particular pattern that will hold throughout the animal scale, simply on the basis of a study in one species. Stone's study of pubertal behavior in the rat, and his stress upon the endogenous, genetic, and maturational factors, may prove correct; but this will not make his conclusions binding for other species. Zuckerman,[1] who has enjoyed rich opportunities for observation, writes of apes and monkeys:

> In describing our present knowledge of the socio-sexual development of apes and monkeys, this chapter has also revealed how scanty this knowledge is compared with the established data concerning similar developments in lower mammals. The rat and guinea pig develop the effective elements in their mating adjustments suddenly and dramatically at puberty. They appear as the final elements in a gradually unfolding pattern of motor mechanisms. Apes and monkeys, as the facts have shown, seem to be entirely different. Almost every element in the series of motor mechanism concerned with their mating behavior appears early in prepubertal life, to become synthesized into the effective mating response long before physiological sexual maturity is reached. Such maturity provides only the final direction and force to these activities. Thus in many ways monkeys and apes run parallel to human beings in their sexual development. Facts are not yet available to indicate definitely in what part the perfected sexual responses of the subhuman primate may be innate, and in what part conditioned. Those that are available suggest that social conditioning plays the bigger part. The investigation of the problem is complicated by the monkey's sociality, by its greater vitality, by the multitude of its investigatory activities, and by the rapid adaptation it shows to new situations.

And if social conditioning is found to have importance for primate sexual behavior it will certainly have an even more important role in human development where the social, cultural, and traditional factors have so much greater weight than at any other point in the animal scale.

[1] Zuckerman, S. *The social life of monkeys and apes.* New York: Harcourt, 1932. Reprinted by permission of the publishers.

THE APE AND THE CHILD

Are Higher Animals More Dependent upon Environmental Factors?—Experimental studies of insects, tadpoles, and white rats have served to illustrate the operation of both maturational and environmental factors, but all the studies devoted to the lower forms possess definite shortcomings when we seek to apply their findings to the highest animals. The possession of a more highly developed nervous system, an obviously greater plasticity and learning capacity, and a relatively long period of infancy and dependency, all suggest that what may be cared for in the lower organism by growth factors independent of external influences (other than the physical and chemical ones necessary for the maintenance of life) will show a much greater trace of environmental influence in the higher animal. Tadpoles may develop their swimming reactions without practice, simply through the continuing growth of sensorimotor arcs; but it does not follow that walking, in the child, develops similarly.

Psychological literature has been seriously lacking in controlled experiments upon the higher animals. Their length of life has offered one stumbling block, for the labor of adequately controlling a long developmental period must have made many an investigator pause; and in the case of the human child there are human reasons for the failure to experiment. Most mothers would prefer to have their children grow up by the usual rule-of-thumb methods than to risk the possible distortion that might come from particular types of forced training, and no one would risk subjecting a child to the isolational type of development where it is deprived of what might prove to be vitally necessary contacts.

It is not surprising, therefore, that with a foundation mainly of anecdote and speculation, psychological interpretations of human development have been in serious conflict with one another.

Thus, the accounts of the wild boy of Aveyron, Kaspar Hauser, and the wolf children of India have been interpreted as demonstrating the vital importance of a human environment for normal development. On the other hand, it has been suggested that these youngsters were feeble-minded in the first place, and possibly were abandoned for that very reason.

The wild boy of Aveyron, found roaming in a French forest, was probably eleven or twelve years of age when studied. When found

he was naked, dirty, scarred, living on what he could find in the woods, altogether more of an animal than a human being. In spite of the best efforts of the French physician Itard, who seriously tried to "domesticate" him, he remained at a decidedly subhuman level, and the attempt to educate him was counted unsuccessful. Similarly, Kaspar Hauser, thought to be an heir to a title in some German family and removed by political schemers until he was released from his solitary confinement at the age of seventeen, could scarcely walk, could speak one sentence, and could not understand what was said to him. He, too, responded but slightly to training. And the two wolf children found near an Indian village when the natives dug out a wolves' den, ran about on all fours, grunted, barked, and growled like animals, ate and drank like dogs—pouncing upon and devouring birds and small animals, were likewise but partially responsive to human influences. The elder of the two, for example, lived until she was six, and although she acquired a vocabulary of about one hundred words, her mentality remained that of a child of but two or three. Her younger sister never learned to talk. If forced to do so, they could stand; but it was apparent that it was an unnatural posture, and they did not run erect. Such, at any rate, are the accounts which we have.[1] But so unsatisfactory are these accounts, so incomplete our data, that we do not know how to interpret them. Their failure to respond to training may simply illustrate the ill effects of delay, or the interference of previously established habits. On the other hand, we cannot be certain that we are dealing with normal subjects, and in the case of the wolf children there is some question as to the facts themselves.

An Experimental Study.—It is with great satisfaction, therefore, that one turns to the study carried on by the Kelloggs.[2] One observational study of this type is worth volumes of speculation, and the experimenters deserve the gratitude of all psychologists for their ingenuity and persistence in carrying out what was obviously an arduous and confining experiment. The proposal of the Kelloggs was to "adopt" an infant chimpanzee into their own household,

[1] Squires, P. C. Wolf children of India. *Amer. J. Psychol.*, 1927, 38, 313–315.

Itard, J. G. M. *The wild boy of Aveyron.* Trans. by G. and M. Humphrey. New York: Century, 1932.

Tredgold, A. F. *Mental deficiency.* Baltimore: Wood, 1922.

[2] Kellogg, W. N., and L. A. Kellogg. *The ape and the child.* New York: McGraw-Hill, 1933.

raise the young ape along with their own child Donald, a boy of 10 months, giving the animal a completely human environment in so far as possible, and in every way to equate methods of treatment and handling. The diet, the sleeping quarters, the discipline, the baths, the airings, the experimental tests and measurements, were all to parallel each other. Moreover, the training of each one was to proceed in a normal, that is to say, *incidental*, manner. The experimenters were not interested in seeing how many human "tricks" could be taught to the ape, or in forcing development along specific channels. At the time of adoption the ape was seven and one-half months of age, the child ten months, and the experiment continued for nine months. Although the ideal experiment would have demanded an earlier adoption of the ape, conditions did not permit this to be done; in spite of this shortcoming, the experiment succeeded in unearthing valuable, and in some cases rather startling, material.

Similarities in Action Systems.—Whoever has watched the caged apes and monkeys at the zoo has had the phrase of Nietzsche, "Human, all too human," given a new meaning. Even reared in this altogether inhuman environment their ways are startling in human resemblance. Their very body build, musculature, their whole action system, permits so many postures and gestures of the human type that one appreciates what it means to say that behavior is the functioning of bodily structure. In the Kelloggs' study, where environments, too, are equated, the resemblance stands forth from their pages with even more startling clarity. We observe, through the eyes of the experimenters, the young ape wiping her mouth with the back of her hand when she has had food or drink, sucking her thumb, rubbing her eyes when sleepy, curling up in typical childlike sleeping postures, giving a sigh of relief when some distressing situation is over. Or we see her playing the familiar game of dropping things from her high chair, or tracing lines on a fogged area of the windowpane, or shuffling along in her shoes, raising a cloud of dust on a freshly lined tennis court. So, too, she shows the aftereffects of an illness in a regression to more dependent and infantile habits. We see Gua, the infant ape, rushing to greet her "father," whose absence she dislikes, and we see her scrambling back on her chair at the sound of returning footsteps when she has slyly violated the command to remain on a chair. So, too, like most children, she delights in "showing off" before an audience;

and at an earlier age than the child she is helping the adults who dress her by holding her head forward for her bib or lifting her arms for her garments. And, again before the child, she seeks a kiss of forgiveness after she has been disciplined, or has been scolded for transgressing some well-established household taboo. Many of the postures and gestures grow naturally out of her body build, but it is apparent that some of them are the specific products of a human situation.

Differences in Developmental Rates.—One of the sharpest differences between the two subjects appears in the comparison of their

FIG. 50.—Donald and Gua "playing ball." At the time of the photograph, Donald was 18½ months, Gua, 16 months. The experimenters assisted this behavior by verbal directions. (*From W. N. Kellogg and L. A. Kellogg. The ape and the child,* p. 130. *New York: McGraw-Hill,* 1933.)

rates of development. The ape matures more rapidly than the child. Although, so far as is known, the life span of the two species is approximately the same, infancy is a more rapid period of growth in the case of the ape. Within the period of the experiment the child increased 10 per cent in stature, the ape 17 per cent; in weight 19 per cent against the ape's 89 per cent; and an average of 31 measurements shows an 11 per cent increase for the child as against a 19 per cent increase for the ape. Other evidence from X-ray study of bones, the teeth, the closure of the fontanels, measures of reaction time, and strength, all show the ape to be physiologically

advanced. At one year, according to the investigators, the ape has the agility of a four-year-old, and the strength of a child of eight. This greater strength of bone and muscle will enable the ape, when the child is barely able to maintain an erect posture, to climb up the clothing of an adult without using her feet, lifting her weight by her arms alone, and to walk, run, jump, and climb in an altogether "advanced" manner. Her biceps, according to the Kelloggs, when relaxed feel as hard as the tensed muscles of many men. Thus we observe a developmental rate that appears to be a constitutional affair. Her body chemistry runs on a different plan, and although (with the exception of her vegetarian tendency and greater intake of liquids) the diets of the two children are practically the same, the ape is building bone and muscle at a greater rate. The observers note, too, that at an early age she shows the need of much less sleep than the child.

As would be expected, the developmental rate has its behavior counterpart. From the start, Gua could be led by the hand, and is walking unaided a distance of 3 meters when she is nine months of age, and at nine and one-half months half her outdoor play is in the upright posture. The boy is taking his first steps, unaided, at twelve months, and walking freely at the fifteenth month. At seven and one-half months Gua is climbing into her high chair, a feat equaled by the boy at eighteen and one-half months. At fourteen months she had climbed a ladder to the height of 5 meters, swinging down on its underside, hand over hand, and she had managed to climb to the top of an auto via the door handle and window ledges. Similarly precocious were her jumping activities: any higher piece of furniture seemed to be regarded at once as a vantage point from which to leap to some lower surface. Moreover, her spatial adjustments possessed an accuracy which Donald's did not achieve, at least in these early months. While Donald was first walking he did not seem to pay any attention to upturned edges of rugs or the feet of his elders or other obstacles, but shuffled into them only to fall unless caught. But when Gua is but nine months of age she is walking gingerly, as, for example, over a tangle of electric wires, and although by the time her feet have reached the obstructions her glance is directed far ahead, she seems to be prepared for the obstacle and somehow carries it in her prepared postures, like a schema. It is not merely that she walks carefully; rather, her adjustment is neatly spaced for each item. So, too,

the speed and timing of an act such as catching a fly, with its stealthy approach and quick swoop with closing fist, is far in advance of anything which the human child of the same age can show (thirteen and one-half months).

A similar precocity was observed in her sensory equipment. On the whole, her receptors were much more sensitive than the child's and her sensitivity to bright lights led her to seek shaded play spots. She responded to slight sounds which were apparently below the threshold of the adult experimenters, and olfactory cues were obviously used as a basis of recognizing persons. Both tactual and auditory localizations were superior to the child's; in the latter case the errors, in degrees, were measured experimentally. Placed blindfolded in the center of a 7-foot square, the subjects were called by the experimenter, and the point at which they crossed the boundary marked and compared with the true localization. Errors averaging 40.2° for the child, and 25.9° for the ape, were obtained when the subjects were sixteen and thirteen and one-half months, respectively.

Ape Handicaps.—Not all Gua's physical traits could be counted an asset. For the most part her joints were more flexible and permitted a range and a freedom of movement not enjoyed by the child. Placing hands (and indeed, feet) above and back of the head was a simple matter for Gua. But the wrist and finger joints were less supple, and permitted forward movement only. Although she occasionally displayed a version of it, the normal thumb opposition was lacking, and the fine pincerlike manipulation of thumb and forefinger used readily by the child in picking up small objects was beyond her. Coupled with her strength this defect emerged in a gross type of grasping and a boisterous and destructive type of manipulation, rather than the more minute and studied handling of the child. Although her vision was delicate enough (she was seen watching the dust particles in a beam of light) to permit it, the finer and more extended manipulations were not characteristic of the ape. She did, however, become interested in pictures before the child, and while the child was still more interested in the gross turning of pages and slapping of surfaces, Gua was pointing out details on the pictured page.

So, too, the balance in length and strength of her limbs, plus the all-fours coordinations already established at the time of her "adoption," could not be said to facilitate the upright walking posture. The all-fours habit of locomotion already established must have

stood in the way of other coordinations, and her long and strong arms made these an easy support to rely upon. Her body build suggests what observers have agreed, namely, that it is never "natural" for an ape to walk upright. Left to themselves, they do not achieve it; and certainly, in Gua's case, the establishment of the all-fours pattern must have made the upright posture less easy to acquire. Adopted earlier, she might have shown the upright coordination at a still earlier period than the one noted. Even so, her developmental schedule was ahead of the child's.

A Case of "General" Maturation.—The picture of the young ape's development offers one of the best demonstrations of what is meant by the concept of general maturation. It is not merely that the ape's body structure and ape instincts (if such there are) mature at a more rapid rate; but *her capacity to learn, and to take on human patterns that would never have appeared in her normal environment, increases at a more rapid rate as well.* Thus, she was eating with a spoon before Donald (thirteen months as against seventeen and one-half). Her superior motor development was polymorphous enough to adapt itself to the arbitrary environment imposed by humans. So, too, her success in specific learning experiments, in extracting hand and foot from a rope tied on the member with a slipknot, and in securing a suspended cooky by shoving a near-by chair underneath it, placed her ahead of the child. In the "suspended cooky experiment" her solution was clearly of a superior type as well, for she seemed to adapt to changed positions more readily, keeping her eye on the objective and adjusting her movements to the goal; whereas the child was inclined to use a more stereotyped response, stringing together in mechanical fashion a chain of movements that had been successful in an early instance. So, too, in using a hoelike tool to rake in a bit of apple behind a screen from which it could be seen but not reached, the ape proved to be the superior performer. And again, in the capacity to delay her reactions, as would be demanded in running to the correct opening behind which one of the experimenters had disappeared with her playmate some time before her release, the ape was the more apt pupil, responding correctly 7 times out of 10 with a 30-min. delay when the child was responding on a purely chance basis at a 10-min. interval. And in opening doors, unlatching screens, "telling" (by gesture and cry) of her bladder and bowel needs, the ape was also superior. Even in such a specifically human type of

performance as responding to words the ape was clearly in the lead until the fifth month of the experiment; but from that point on the child began to lead.

Personality Differences in the Subjects.—Throughout the experiment the ape seemed to be the more docile and obedient of the two. The Kelloggs suggest that this may have been symptomatic of her greater "psychological" dependence. The ape seemed to suffer more from solitude, and clung to her associates, particularly to the male adult, with a tenacity that must have been both trying and confining. Disapproval seemed to be a much more serious thing for her, and until she could get back into the good graces of her mentor, she was quite ill at ease. Punishment of any sort left her disturbed, until reassured by some friendly sign, preferably a kiss of reconciliation. The child, on the other hand, was much more content to play alone, and made friends with adults much more freely. It is possible that Gua's dependence had something to do with her adoption into a strange environment, and it is possible, further, that all this conspired to make the social stimulus of approval and disapproval much more potent in motivating her learning.

One sharp contrast between ape and child in this matter may be noted. Whereas Gua responded promptly to command, and Donald frequently had to be repeatedly warned, the child would retain the inhibition much longer than the ape. As soon as the observer's back was turned the ape would be back at the forbidden performance, and her sole concern seemed to be to "keep in with the boss." One amusing solution to a conflict situation also illustrates the forces at work in shaping Gua's conduct. Told to remain on a chair near the table where the experimenter was working, but separated by some little distance, Gua solved her difficulty by drawing the chair up so that she could obey the command and at the same time place her hand upon the experimenter. So, too, she would at other times keep one eye upon the face of the experimenter at the same time reaching her hand in the direction of the forbidden objective. One is tempted to posit a pair of "forces" and to look upon her action as a kind of psychological resolution comparable to that which the physicist deals with. Her dilemma, when left with a strange adult, suggests this description. Whimpering, lonely, and fearful, she dares not approach too closely to the stranger, and yet she must follow him about; so she maintains a certain distance that seems to be a balance between the forces which attract and at the same time

repel her. Her conduct seems much more explicable on the basis of such impulsions, at any rate, than on the basis of hypothetical instinctive (and possibly neurological) mechanisms which unwind to produce a certain path of action.

Pace vs. Form in Development.—The general impression conveyed by the study is certainly one of a very plastic set of potentialities, in both subjects. Maturational, and genetic, factors may set the developmental pace; but in many cases the form and direction of development depend upon shaping circumstance. Some structural-physiological traits may provide "predispositions," as in the visual sensitivity which results finally in the ape's learning to play in certain shaded places. But the assumption of the upright walking posture, never natural to the ape, without an unusual process of forced training, certainly argues for plasticity. That she did this as naturally as the child, and indeed at a more rapid rate, in spite of interfering habits previously established, certainly argues for the polymorphous character of our original nature. It would appear that our genetically determined structures have many more potentialities than any single natural environment can reveal. Their final form is thus dependent upon the spacing and timing of those shaping contingent circumstances which play upon the individual from without. Afloat on a pond, the young moor hen may be sent into her characteristic dive by the barking of a puppy on the bank; but when she meets the same barking pup on a hard, dusty road she does not dive. The supporting stimuli call for a different configuration of action. And where the individual's development leads him through characteristic supporting patterns and his subsequent behavior bears their mark, as in the walking of Gua, we have no right to speak of the form of these activities as genetically determined. In fact, the shaping circumstances are within our control, and the history known, in a way that is not true of the gene-determined structure.

Reciprocal Influences.—In some respects Gua is "more human" than the child, for she takes on the ways of her adult environment more rapidly than the infant. When she has been in a human environment for but three weeks, she climbs into her high chair when she sees her food being warmed; and the whole account of her precocious development, given above, shows to what an extent it is possible to attach her reaction equipment to the human environment. And there is no question as to her acceptance of the child as play-

mate. When he is taken away she is desolate, and if she awakens from her nap before the child she waits for him and, unless prevented, will go to his nursery door and open it. Each of the subjects seemed to be "electrified" into action by the other; and each tended to identify himself with the other, crying imitatively when the other was hurt or punished, or embracing each other in a way which could easily be interpreted as comforting. And the ape's name is given as one of the three words possessed by the child at eleven and one-half months.

It is undoubtedly true that much of the ape's speedy acquisition of typically human reactions depended upon its being accepted on exactly the same plane. Had she been accepted merely as a "good doggy" and had she remained caged, part of the time, in spite of her speedy rate of maturation and general intelligence the patterns would have been different. Both from the standpoint of motivation and from the standpoint of shaping the patterns, the authors are inclined to stress the social as more important than the physical environment. We learn that the experimenters fed and cared for the two in as nearly identical a manner as possible, that they both slept in cribs, wore diapers, shoes, and met the same routine of tests. But it is the picture of the two playing ball, of the ape feeding Donald, looking at pictures, comforting the crying child, etc., which testifies to what an extent the social environment has been equated.

But the ape, it must be remembered, is a part of the child's environment, and we can see that the influence has been a reciprocal one when we note that this child seems to be precocious in climbing. We see him copying the ape in removing the upholstered cushions from a piece of furniture, and grasping the trousers of his father as the ape had done in learning to walk—although this method of training had not been used with Donald.[1] We hear him giving a "food bark" which was characteristic of the ape, and see him trying to pick up crumbs with his lips. (Gua regularly resorted to this,

[1] The child was given a "walker" and as commonly happens passed to the upright posture without the crawling and creeping stages. The ape was so far advanced at the age of adoption that the experimenters could "give him a hand" from the start, and the male experimenter hit upon the expedient of allowing the ape to walk behind him, grasping his trousers and peering between his legs. Gua developed a curious little skip in her walk in this fashion, for the adult's longer legs covered the ground too fast for her short steps. This little hop-and-skip, never given at other times and here always with the right leg, became a regular part of locomotion thus assisted.

for her relatively poor manual coordinations did not include the finely adjusted pincerlike grasping of the child.)

Human Capacities.—In spite of the speedier development of the ape, the child possesses capacities which carry him ultimately beyond his rival. One item appears to make him a superior manipulator. His finger-thumb opposition and fine pincerlike grasp, together with a more sustained attention, yield a more careful and prolonged observation of the objects he is given, and in consequence he will acquire superior skills in the end. He is also a superior imitator, and more responsive to verbal and gestural directions; and in spite of a slower perceptual and sensory development at the beginning, by his twelfth month he is surpassing the ape in developmental tests.

Particularly, the child excels in language. At this point the experimenters departed from their policy of purely incidental training, but in spite of repeated attempts to teach the ape a relatively simple word (papa), nothing approaching human speech was developed. The ape did possess, it is true, four words, if we count the "emotional" cries which remained unchanged throughout the experiment. These cries—the food bark, a plaintive "oo-oo" that was used indiscriminately in "unpleasant" situations, a bark of aggression or anger usually accompanied by other gestures of attack, and a shrill screech or scream—did have a symbolic value for the human audience. The food cry came to have a general meaning of "yes," or of acceptance, and the "oo-oo" clearly indicated her distress, but beyond such generalized symbols, and the facial expressions and pulling and pointing gestures, the ape failed to achieve a language. As a result of his failure to teach the ape to speak the experimenter concludes: "Although the possibility may still remain, we feel safe in predicting, as a result of our intimate associations with Gua, that it is unlikely any anthropoid ape will ever be taught to say more than half a dozen words, if indeed it should accomplish this remarkable feat." In view of the fact that the ape possesses an articulatory mechanism (lips, tongue, vocal cords, chest muscles, diaphragm) which provides the necessary effectors for voice production, this is the more remarkable. Nor can we, in view of the ape's intelligence, manifested in so many other ways, say that its failure lies in simply "having nothing to say." One falls back, therefore, upon those "central connections" whose disturbance in human subjects produces the phenomenon of aphasia. Apparently the ape

failure must lie in the faulty neurological endowment. The difference appeared even before the child was truly speaking, for the ape never engaged in that babbling sort of vocal play which yields the basic elements out of which adult speech is built; and failing in these elements of speech there was nothing upon which to build, later on. This makes it all the more remarkable that until the fifth month of the experiment she was able to *respond* to more words than the child. (As late as the fourth month she was leading, with 14 specific responses to words, as against the boy's 8.)

Summary.—The experiment is best summarized, I believe, by gathering together, as the investigators have done, the likenesses and differences which were recorded, and classifying them as to their probable causation.[1]

Of the *differences* between the subjects which can scarcely be attributed to the environment, we may name:

Such physiological items as higher blood pressure, lower pulse rate, greater water consumption, possession of fewer sweat glands, delayed appearance of canine teeth, all of which characterize the ape.

Such sensory differences as were noted in the fields of vision, hearing, smell.

Such structural traits as were revealed in the more mobile mouth, length of forearm.

Such behavior traits as the greater propensity to chew, inability to pick up small objects, gross manipulation, inferior imitation, short attention span, poor articulation; and the speedier maturation of reaction times, muscular strength, agility in walking, climbing, superior ability to localize sounds, and of memory and the ability to learn the tasks assigned.

Of the *likenesses* which similarly cannot be attributed to the environment, one may list:

Such natural use of similar structures as is noted in sleeping posture, the nodding head of the tired subject, rubbing eyes, wiping mouth, laughing, the "covering up" in response to tickling, etc.

But beyond these, and other likenesses, which we might describe as the natural functioning of similar structures, one is struck with:

The assumption of the upright walking posture.

Such "games" as playing with shoes, faces, balls, telephone, typewriter, and the social play of infant and child such as is shown in rolling a ball back and forth, scribbling on paper.

Willingness to bathe in large bodies of water (which does not appear to be common with apes reared in a natural environment).

[1] Cf. *The ape and the child*, Chap. 13, pp. 307 ff.

The response to words and phrases (Donald, 68 at eighteen and one-half months; Gua, 58 at sixteen months). (At sixteen months of age Donald had responded to 39 words.)
The extensive list of skills acquired in the course of eating, dressing, bathing, bowel and bladder control, etc., as well as in the specific tasks experimentally studied.

Other patterns less easy to classify are:

The ape's avoidance of human beings other than those regularly in the experimental household.
The ape's food preferences.
The greater psychological dependence of the ape.
Such "games" as playing in the sand, dust, etc.

Of the *differences* which were noted the experimenters were unable to attribute any with certainty to the environment: although, as has already been indicated, it is possible that the greater dependence and the fear of other adults may be traceable to the sharp change in her environment at the time of adoption. It is clear that most of the differences are due to structural-genetic factors upon which the environment had little or no influence. The whole rhythm and tempo of the ape's development, the growth of capacities, and the resulting rates of acquisition are likewise internally regulated. It is in the *likenesses* between the subjects that the environment is most clearly operative. Most instructive is the demonstration that the intrinsic factors serve to impose *limits* and *rates* of development, while the extrinsic ones provide *direction*. In some instances the intrinsic factors serve as *predisposing* factors, as, for instance, in the ape's climbing, boisterous and destructive manipulation, tendency to bite objects and to pick up small objects with lips rather than with the fingers. Instead, however, of viewing an instinctive disposition as the core around which habits are to be organized, it seems wiser to look upon the inherited structure as furnishing the raw materials which are capable of being shaped into a variety of patterns. The ape's structure lends itself easily to an all-fours method of progression. It can also be molded into the upright patterns taken by human beings. Left to himself, in all probability the human being would take an upright posture naturally, but the case of the wolf children suggests that under other circumstances the all-fours method is also natural.

It is this "loosely organized" character of the inherited mechanisms that is typical of the higher animal. With man and the apes

the "instincts" seem to lose their blindness and fixity. The ease with which habits are formed permits an infinite variety in the assemblage of patterns, and it also robs the concept of instinct of much of its applicability. When such a basic pattern as locomotion is seen to be responsive to environmental changes there does not seem to be anything which can be called instinctive, deservedly, save the simple reflexes and the structural raw materials. Such raw materials are far removed from the purposes of the adult, and if human nature has anything like permanence and continuity it must be by virtue of a continuing human environment, a social tradition, and more or less permanent institutions like the family. When these shaping forces change, as they are now changing under our very eyes we may expect human nature to change. Human organisms may set limits and even provide predispositions, but the field within which variations are possible is still extremely wide. Those political philosophers who have tried to found our social institutions upon an ingrained human nature have succeeded merely in putting the cart before the horse. The ingrained materials are, of all things, plastic. It is the institution, man-made and hoary with tradition—and yet evolving, which gives these materials shape.

The Study of Identical Twins

Although the psychologist is seriously hampered in performing controlled experiments upon developing human subjects, nature is not subject to such socially imposed inhibitions. When, as in identical twins, nature produces two individuals with exactly the same heredity she has provided the customary experimental "control." It remains for the observer to study the development of such pairs under varying conditions, and although it will seldom be possible to separate large numbers of such subjects according to plan and to follow rigorous and independent schedules, occasionally this can be done for a limited period, especially where the training given to one member of the pair is considered advantageous. Beyond this there will be the separations enforced by circumstances which lie entirely outside the psychologist's schemes, but which nevertheless furnish grist for his mill.

A brief word concerning the genetic endowment of such twins may be in order. Twin births, constituting about 1 per cent of all births, yield two sorts of twins, identical and fraternal. The identical twins constitute from one-fifth to one-fourth of the twin births, and are

always of the same sex and remarkably alike in physical endowment. Fraternal twins, on the other hand, do not resemble each other more than ordinary brothers and sisters, and may be both girls, or both boys, or boy and girl. The remarkable physical resemblance of the identical twins, and the fact that they are always of the same sex, is explained by the biologist as due to the fact that they spring from the same egg, and have an identical endowment of chromosomes (the bearers of hereditary characters).[1] Those who would find environmental factors at the basis of bodily structures, and who are prepared to study the influence of a prenatal (maternal) environment, will do well at this point to note that the maternal environment fails utterly to produce the identity in the fraternal twins which similar genetic endowment produces in the case of the identicals.[2] Fraternal twins lack this identity in heredity, and when we attempt to compute the chances of identity in two individuals arising from different eggs and sperms (remembering that man has 48 chromosomes) our calculations produce figures of such astronomical dimensions that for purposes of understanding we might well say that the chances of identity are nil.[3]

Physical and Mental Resemblance.—The physical-structural resemblances in the identical twins are indeed remarkable. Here the imperfect and incomplete division of the "Siamese twins" has completed itself. Hair color, eye color, texture and coloring of skin and hair (even the distribution of freckles), the size, shape, and arrangement of teeth, features of the face, form and intimate structure of ears, body build, tone of voice, papillary ridges of hands and fingers, lines in the palms of hands and feet, all show remarkable duplication. Sensory traits, visual acuity and range, auditory

[1] Morgan, T. H. Mechanism and laws of heredity. In *Handbook of experimental psychology*, pp. 109–154. Ed. by C. Murchison. Worcester: Clark Univ. Press, 1934.

[2] It is worth noting, however, that the lack of identity in the prenatal conditions of development does produce a divergence in structure, even in identical twins. Besides the minor variations in hair distribution, freckles, papillary ridges and lines, moles, etc., there is the frequent difference in handedness. Most noteworthy is the difference in strength, weight, and general vitality, appearing at birth. Often this difference persists, and one of the twins will take on more of the traits of extroversion, leadership, sociality, aggressiveness—this in spite of their identity of inheritance.

[3] With 48 chromosomes, the biologist calculates that there should be 282,429,-536,481 possible combinations, assuming differences in the units of each pair. (See Morgan, T. H., *op. cit.*, p. 139.)

acuity and range, are likewise similar; and post-mortem study has revealed a similar identity in convolutional patterns in brain structure. There are also on record cases which show a remarkable identity in medical history: brain tumors, psychoses, and other diseases may be duplicated.[1]

To what extent will such an identity in original nature, as evidenced in bodily structure, produce an identity in mental make-up? Or, stating the problem differently, to what extent will divergent environments, special training, give different form to identical endowments—as identical, at any rate, as can be found in nature? That the resemblance carries over to the mental traits, under ordinary conditions, has been shown by a number of studies. In Binet test scores, identical twins show a resemblance measured by the correlation figure of .90, whereas siblings give a figure of .50, fraternal twins of .65 to .70, and cousins a value of .20 to .25. Unfortunately these figures do not admit any simple and clear-cut interpretation, for there are other than genetic factors at work. Why should the fraternal twins show any greater resemblance than siblings, if the genes are solely responsible? Does it not indicate that being born at the same period in the family history and meeting the same events at the same periods (and ages) has a greater chance of inducing identity? And is it not equally possible that the identity in sex and appearance may call for an identity of treatment, of reaction from the social environment, in the case of the identicals, which is not produced in the other cases?[2] And may not the lower figure for resemblance of cousins be due to the fact that the environments are also more divergent?

Separated Identical Twins.—There are on record a few cases wherein the twins have been separated at an early age, and these give us some hint as to the relative roles played by heredity and environment, in such general measures of mental resemblance. H. J. Muller[3] has reported the case of two sisters, identical twins, who were separated at two weeks of age and who did not see one another

[1] Even in their differences there is frequently a symmetry and order. Often one is right-handed, the other left-handed, and on occasion there are reversals in hair whorls, and the papillary ridges and lines.

[2] Cf. Wilson, P. T. A Study of twins with special reference to heredity as a factor determining differences in environment. *Hum. Biol.*, 1934, 6, 324–354.

[3] Muller, H. J. Mental traits and heredity. The extent to which mental traits are independent of heredity, as tested in a case of identical twins reared apart. *J. Hered.*, 1925, 16, 433–449.

until their eighteenth year, and in the years from eighteen to thirty lived apart nine-tenths of the time. Both were energetic, capable, popular, active in clubwork. One had had, and the other nearly had, a nervous breakdown in the late teens, and both had had two or three attacks of tuberculosis almost simultaneously. Intelligence test scores showed close resemblance, although their general level of attainment departed from the average. Tests of nonintellectual factors, such as motor reaction time, association time, social attitudes, emotions, and "will-temperament" scores showed a greater divergence than one would expect in any chance sampling. On the face of it, such resemblances as are indicated by the nervous breakdown, the attacks of tuberculosis, and their similar I.Q.'s would indicate that common constitutional and intellectual endowments have produced their fated results in spite of divergent environments; but that certain social, emotional, and other nonintellectual traits show the effect of this divergent training. But a clear interpretation is not so easily achieved, for we learn that, though separated, they lived under similar social and economic conditions in the Northwest. Is it not possible that such levels of attainment as are finally measured are as much a matter of similar stimulating circumstances as of similar genetic constitution?[1] And psychologists have come to question the reliability of many of the motor, emotional, and nonintellectual tests, as a whole.

The embryologist Newman has published similar studies of twins reared apart. His earliest studies,[2] contrary to Muller's, show sharp differences in intellectual attainment. Two sisters, born in London and separated at eighteen months, had lived seventeen years apart, one in London and one in Ontario. After they had lived together for one year they were tested and showed differences in I.Q.'s which were three times as great as the average for 50 pairs of identical twins reared together. On the other hand, the will-temperament tests and emotional reactions showed considerable resemblance. A second set of twins reared apart, one with seven years more schooling than the other, likewise showed (at nineteen years) a marked difference in intelligence, the educated twin attain-

[1] As Muller states the issue: "What the effect might have been of changing the social class, the country, or the color (were that possible) of one of them, it would be impossible to predict."

[2] Newman, H. H. Mental traits of identical twins reared apart. *J. Hered.*, 1929, 20, 49–64, 97–104.

ing superior scores. A pair of twins, brothers, were tested at the age of twenty-three and showed similar scores, although one was a country boy and the other city bred. Newman found marked personality differences, however, the city-bred twin appearing dignified, reserved, self-contained, more experienced, and both less fearful and less friendly. His country-bred brother was described as a typical country boy, friendly, laughing readily, not at all upon his dignity, etc.

In a more recent study,[1] Newman, Freeman, and Holzinger have studied the likenesses and differences—both mental and physical—in 100 pairs of twins reared together (50 pairs of identical twins, and 50 pairs of fraternal twins of like sex) and of 19 pairs of identical twins who had been separated. Their results give as adequate a basis for generalization as may be had at the present time. The study shows that no sweeping generalization as to the relative strength of the two factors, heredity and environment, can be made; for the weight of either factor depends upon (1) the trait which is being measured and (2) the amount of divergence involved in each of the two factors.

With respect to the first point the study shows that when we compare the fraternal and identical twins reared together (and in presumably like environments, therefore) the identical twins are more alike in physical dimensions, in intelligence, in educational achievement. The measures of personality traits which were used did not show the resemblance between the identical twins to be significantly greater. Ranking the traits in the order in which they seem (under the conditions of this comparison) to be genetically determined, the authors list: physical traits, general ability, achievement, personality and temperament.

The authors' second point may be illustrated by making two sorts of comparisons and determining the weight of each of the two factors, heredity and environment. For example, the authors compare identical twins reared together with identical twins reared apart, and applying statistical techniques to determine the role of each factor in the variance assign the environment a value of 87 per cent in determining weight, 59 per cent in determining Binet I.Q., and 87 per cent in determining achievement. But when they compare identical and fraternal twins (reared together) these same traits assign to the

[1] Newman, H. H., Freeman, F. N., and Holzinger, K. J. *Twins: a study of heredity and environment.* Chicago: Univ. of Chicago Press, 1937.

environment values of 21, 31, and 36 per cent. In other words, where the environmental differences are large (as compared with heredity) the share of influence exercised by the environment will appear to be large. If, however, the genetic differences are large in comparison, the share of heredity appears to be large. The authors conclude by agreeing with a remark of Jennings's to the effect that what heredity can do the environment can do also.

Developmental Correspondence in Identical Twins.—A study by Gesell and Thompson[1] shows that the correspondence between identical twins extends to the rhythm and rate of development. It also suggests the same maturational factors which were emphasized in the early studies of animal development, for the appearance and course of improvement of locomotion and manual dexterity, in the items measured, seems to take its own course independent of several weeks of specialized training.

The identical twins, T and C, of this study, had been in a nursery home since their fifth week, their mother having died soon after their birth. Except for an attack of intestinal intoxication (19th week) which sent both twins to the hospital and involved rather rigorous treatment, and an infection which enforced isolation upon twin C from the 45th to the 51st week, their development followed a regular, if slightly subaverage course. During the first 18 months some 15 developmental examinations were made, and the records of 13 of these involving some 612 separate ratings showed 513 behavior items that were identical or nearly so. Motion-picture records of the test performance, together with stenographic reports of the observers' running comments on their behavior, permitted a detailed analysis later, at leisure.

Similarity in Behavior.—As an indication of correspondence, the authors' comments on one of the tests, "pellet prehension," may be quoted:

A small pellet, 7 mm. in diameter, was placed on a table top before each child, within easy reach. At 28 weeks both the twins, being somewhat retarded in their development, were visually unheedful of the pellet, though they definitely regarded a cube. At 38 weeks they addressed themselves in an identical manner to the pellet. The hands were placed in full pronation, the fingers were fully extended, and spread apart in a fanlike manner. The thumb was extended almost at right angles. The

[1] Gesell, A., and Thompson, H. Learning and growth in identical infant twins. *Genet. Psychol. Monogr.*, 1929, 6, 5–124.

motion-picture record of the twins' attack upon the pellet shows an almost uncanny degree of identity in the details of postural attitude, hand attitude, approach, and mechanism of grasp. At 40 weeks there was a crude raking attack upon the pellet; at 42 weeks this raking approach was replaced by a poking with the tip of the index finger. These changes in prehensory pattern occurred contemporaneously in both children.[1]

The correspondence is the more striking in view of the fact that "in general make-up, the behavior picture is one of rather attractive though subaverage normality." On the other hand, their general

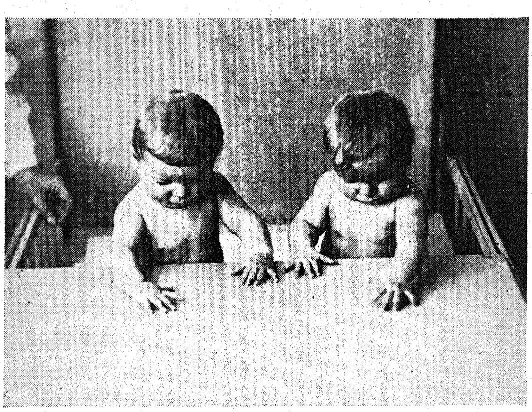

FIG. 51.—Pellet test. Twin *T* (identified by wrist band) and twin *C*, of the Gesell and Thompson study, shown simultaneously approaching a pellet. (*From Arnold Gesell and Helen Thompson. Learning and growth in identical infant twins. Genet. Psy. Monogr.*, 1929, vol. 6, no. 1, 11. *By permission of the publishers.*)

postural and locomotor control was relatively advanced, so that we might speak of a correspondence in developmental profile. So impressed are the authors with the remarkable identity in the test performances of the two subjects that they feel that by no stretch of the imagination could such identity be produced by "the cunning arrangement of environment and of conditioning stimuli." They ask, "How can the environment, even of twins, accomplish such architectonic miracles?"[2]

A Controlled Experiment.—In order to demonstrate the preponderating influence of internal developmental controls the authors began

[1] Gesell, A., and Thompson, H. *Infant behavior*, pp. 305–306. New York: McGraw-Hill, 1934.

[2] *Ibid.*, p. 306.

an experimental training period when the twins were 46 weeks of age. Tested at this time, their locomotor development was practically identical. In a stair-climbing test, in which the twins were placed at the bottom of a four-step flight, "each twin lifts one foot when placed at bottom of staircase, but neither goes further in an effort to climb."[1]

Then followed a six weeks' training period in which twin T was given special stair-climbing training each day. Although the training period was brief (but 10 min.) and no forcible methods were employed, a rather rapid improvement took place. Twin C, in the meantime, was given no definite training and since the playroom contained no steps and the attendants were careful not to induce the children to climb into their chairs, etc., we may regard the second twin as a "control." It is surprising to note, therefore, that in spite of complete absence of specific training twin C, at the age of 53 weeks, promptly climbs the stairs, unaided, in 45 sec. T's best record at 52 weeks had been 26 sec. Then the experimenters gave the "delayed" twin two weeks of training, and at 55 weeks C climbed the stairs in 10 sec., a performance that was superior to T's at the end of a much longer period of training. We seem to be dealing with the same sort of general maturation which appears in the pecking studies, for the age and maturity of the subjects seems to be the significant factor determining rate of improvement under identical training. The authors summarize this phase of their observation:

$T46$ approximates $C46$
$T46 + 2t$ slightly exceeds $C48$
$T46 + 6t$ exceeds $C52$
$T46 + 6t + 1$ exceeds $C53$
$C53 + 2t$ exceeds $T46 + 2t$
$C53 + 2t$ exceeds $T46 + 6t$
$C53 + 2t + 1$ approximates $T46 + 6t + 4$
$T46 + 6t + 27$ approximates $C53 + 2t + 24$

In the above summary t denotes training; T, twin T; C, twin C; and the numerals refer to weeks.

It will be further noted, from the summary, that a later test of the two subjects shows that following their training they tended to return to a similar level, in spite of the fact that the delayed training had placed C in advance. Some indication of the maturation factors

[1] Gesell, A., and Thompson, H. Learning and growth in identical infant twins. *Genet. Psychol. Monogr.*, 1929, 6, 57.

at work is offered by the observation of the authors that the experiment took place at the very period when the walking coordination was emerging. Thus the delayed twin approached the training with a decidedly different equipment, and in her case the climbing was grafted upon a walking posture, whereas *T* made a creeping approach. Writing at a later period, the authors comment: "To this day there is a corresponding difference in the method of climbing progression of *T* and *C*, which may be due to this genetic difference." Although there were signs that the creeping type of climbing in *T* was being broken, there seems to be sufficient evidence that the form of the pattern was conditioned by the level of maturity at the time of the training. This seems to suggest that there is such a thing as premature training, as well as too great a delay. It is possible that the fixation of an inferior pattern of climbing may have delayed the development of the more mature pattern, however it may have facilitated the more infantile form. And the fact that there must have been a great deal of practice in balancing, walking, etc., "off the scene" prevents us from interpreting the results solely in terms of endogenous factors. It is precisely this set of facts, however, which lead the authors to the opposite conclusion, for they write: "This observation [*i.e.*, that in *T* the climbing was grafted on creeping] suggests that the form as well as the incidence of behavior pattern is governed by existing neural counterparts, determined by maturational factors."[1]

One further aspect of the experiment may be touched upon briefly. The training given to twin *T* was also accompanied by training in cube manipulation; but in this case there was no marked improvement, although there was a daily development. Such

[1] From Gesell, A., and Thompson, H. Learning and growth in identical infant twins. *Genet. Psychol. Monogr.*, 1929, 6, 117. Reprinted by permission of the publisher.

If the phrase "maturational factors" is made to refer to an unanalyzed complex of growth and general training, the authors' statement seems substantiated, but the general bias of the investigators inclines one to impute the narrower (endogenous, intrinsic) meaning to their words. When, for example, the authors discover that "on one day they weighed exactly alike to a gram" as they follow the weight chart through a period of hospitalization at the close of which the weights differed by 80 grams; and when the authors find in the similar reactions of the children to an infection, and its rather heroic treatment, a sign that "the correspondence . . . inheres in the very biochemical constitution, supplying a firm matrix for the development of correspondence in psychological make-up," one finds reason for imputing to them the narrower meaning of the term.

development did not appear to come from the specific training, however, for at the end of the period the control twin *C* was found to have covered the same ground without the training. The authors suggest that where changes are taking place from day to day the results of ordinary methods of training are not assimilated and fixated. One day's habits are in part "outgrown" and in part canceled by the new stimulus-response relations demanded by the new maturational level. If the subject's "approach" to the training situation varies, we cannot expect the effect of training to yield consistent or stable coordinations.

Before psychologists accept the authors' complete interpretation of their findings, however, we shall have to know a great deal more about the exact content of the term "maturation." We shall have to have the anatomic and histological studies as well as the behavioral ones. Otherwise we shall be solving our behavior problems by "architechtonic miracles" performed by hypothetical neural configurations which can claim but slightly superior validity to the classic teleology of an earlier instinct psychology.

Supporting Studies.—Facts which support the general picture presented by the Gesell and Thompson findings have also appeared in experimental studies of Strayer and Hilgard. The former studied the development of language in a pair of identical twins, training one of the twins from the 84th to the 88th week, and the other from the 89th week on. Although each twin went through comparable stages, the control (or delayed twin) made greater progress with similar training.[1] A comparable study by Josephine Hilgard, dealing with such tests as scissors cutting, ring toss, walking boards, digit memory and object memory gave similar results. To eliminate any possible difference between the twins, each twin was allowed to serve in part as the practiced subject and in part as control. In addition to her general substantiation of the generalization that training does not transcend maturation, Hilgard found that, regardless of early or delayed training, later tests showed that both twins tended to "forget" to the same level.

The Problem and a Suggested Interpretation.—These facts suggest that there is an optimum point in the developmental cycle before which training is relatively inefficient, and in some cases fruitless.

[1] Strayer, L. C. Language and growth: the relative efficacy of early and deferred vocabulary training, studied by the method of co-twin control. *Genet. Psychol. Monogr.*, 1930, 8, 209–319.

There is no indication, however, that the optimum point is ever determined by purely intrinsic factors. One's level of habit equipment may well form the basis for subsequent training, and it may be the level of babbling habits that determines the relative efficiency of further linguistic training. Thus the child psychologist may be said to have located an important problem, but he can at present give us neither a rule-of-thumb recipe for the most efficient handling of the child, nor a complete theoretical account of the facts he has found.

We should like to know the point at which one should begin training in bladder control, speech, reading, etc., and we should like to know that these points have been determined accurately by experimental methods. We do not want to delay for one moment beyond the proper time, especially if the earlier gains, though made slowly, may be consolidated into a permanently superior level of conduct. On the other hand, if some endogenous factors set the final limits to the rhythm of development, and our most careful efforts will be nullified by these physicochemical factors which are as yet beyond our control, we wish to know that too. If precocious training is merely to be a temporary thing—it were better if we knew it, and patiently waited for a more appropriate period. But the detailed answers to such questions are not yet forthcoming. There is considerable evidence to show that concentrated training is rapidly forgotten and that temporary precocity which is not consolidated by continuous exercise tends to disappear so that the individual drops back to the norm for his age. Thus, one may improve intelligence test scores by drill on particular test items only to find that the child has dropped back to his age level a few months after the training was dropped. A study by Gates and Taylor[1] gives experimental demonstration of this tendency. Two groups of kindergarten children were matched in sex, age, mental age, and memory span, and while one group was given daily practice in repeating digits the other was used as control, *i.e.*, given no training. The practiced group, which averaged a span of 4.36 digits before training, improved to the level of 6.36, whereas the average for the unpracticed group rose to but 5.08. After a summer vacation of four months

[1] Gates, A. I., and Taylor, G. A. An experimental study of the nature of improvement resulting from practice in a mental function. *J. Educ. Psychol.*, 1925, 16, 583–592. See also Gates, A. I. The nature and limits of improvement due to training. *27th Ybk. Nat. Soc. Stud. Educ.*, 1928, 441–461.

both groups were retested, the trained group showing a score of 4.71, the control group of 4.77. This would seem to indicate that the sum total of forces regulating development tends to produce a rather consistent type of progression, and that any attempt to deflect the course of operation must be altogether unflinching. One might also argue that any such attempt is bound to be nullified, in the long run, and that nature must be allowed to take its course. Such, in general, seems the import of the maturationists' argument. However, since we lack the long-time studies necessary to show whether or not early gains can be consolidated with continuous supporting training, and since what we call nature's course contains so many unknown and possibly artificial factors, we need not accept the maturational interpretation as finally proved. One forgets calculus and modern foreign languages unless the classroom training is supported by continued use, and if the amount of forgetting possible in a summer vacation is to serve as a criterion, one could dispense with a large portion of our formal education. The point one should remember is that the engineer who carries his calculus and slide-rule technique into practice does not regress to his former level, and the student of foreign languages who continues to read and converse finds a whole new tradition and culture opening out before him. It is possible that the established norms of the intellectual development of the child also measure the world of the child, and what is expected of him (*i.e.*, his supporting environment) as well as the factors we call maturational. Even the demonstration that there are limits beyond which the developmental curve may not be deflected does not tell us the nature of those limits, nor excuse us from the charge of loose thinking when we lazily dump them into the category of "endogenous," "intrinsic," or "gene-determined" factors.

Developmental Norms of Infancy

Anyone who has watched a human infant develop must be struck with the temerity of the psychologist who proposes to write a clear, yet complete, description and analysis of that process. Beginning with a confusing and chaotic mass of reactions, complicated by both richness of detail and wide variations in performance from day to day, and progressing at rapid speed, the framework of behavior—from the basic postures to the outlines of a personality—stands fully

limned almost before its cloudy outlines can be grasped. At one month the child lies supine, squirming, unable to lift its head and scarcely able to fixate its eyes with coordinated vision, blind and deaf to the "meanings" of all social stimuli; before 15 months have passed it is able to get on its feet and walk unaided, and has already begun to use words and respond to commands. To be sure, compared with the few days required to produce an adult insect, this is slow; but it is also true that the insect usually presents a much more limited set of developmental goals, and its stereotyped behavior permits a simpler and more rigid description. Neither does the insect show the plasticity and variability, the modifications in response to training, which are so characteristic of the human species.

In spite of its difficulty, the task must be attempted. Before one can understand the individual case one must discover the average or norm; and before one can demonstrate the influence of this or that feature upon the course of development one must find the normal or usual course of events. Just as the student of maturation had to determine the normal curve of development of the pecking reaction, so the student of child development is required to establish norms for all the important attainments of infancy. Such basic information is at present incomplete, although recent years have seen rapid progress in sketching the main lines of the picture. Needless to say, in such an incomplete state of knowledge speculation has often run ahead of the facts, and the very sources of the data are sometimes tainted with the bias of the experimenters, so difficult is it to achieve objectivity and to refrain from reading into one's observations those theoretical predilections which have guided, if not prompted, the research.

Prenatal Development.—If the psychologist begins his normative description at birth it is not because he has any notion that behavior begins here, but rather because this is the point at which the subjects are given to him, and at which his techniques are relevant. From those who concern themselves with prenatal development he has learned that by the end of the first lunar month after fertilization the heart is beating, and at the second month, when the fetus is but 30 mm. long, there are spontaneous vermicular movements of arms, legs, and trunk. By the fourth and fifth months the crossed reflex appears, and with it the diagonal, or trot reflex, in which stimulation of one foot releases a movement of the opposite hand

as well as in the member stimulated.[1] In general, the reactions which are released by tactile stimulation are diffuse in character, spreading more or less throughout the effector system. As the fetus approaches full term this massive and somewhat chaotic character is partially replaced by the more sharply defined responses of the neonate. This progression from the diffuse and massive response to the more sharply defined patterns reminds one of the observations of Coghill on Amblystoma, and like this latter observer, those who study fetal behavior incline to a similar neurological explanation of the process of individuation. That is to say, although the medulla and spinal cord are sufficiently developed to function (and Minkowski demonstrated this through operative sections), the cells are still in such an undeveloped stage at the earliest periods in which reflex responsiveness was observed that they provide diffuse channels merely. As the neuroblasts, or primitive nerve cells, send out their dendrites and axons, and these latter make their branching connections with definite cells, the conduction paths arouse more highly specific responses, and the diffuse spreading is checked by inhibitory impulses which help to establish definite borders of conduction.[2]

Minkowski also noted reflexes initiated by the semicircular canals and by the contraction of the muscles. The biological importance of the early development of the vestibular apparatus is related, Minkowski thinks, to the fact that the fetus lives in a fluid environment whose specific gravity is so near his own that the vestibular apparatus must play a greater role here than at any point after birth. Underlying this biological "reason," however, is the demonstrated existence of a differentiated labyrinth apparatus (even in a fetus of 4 cm.) and a functional vestibulospinal tract (probably by the third month). Reflex changes in posture which follow a change in head position resemble those demonstrated by Magnus and de Kleijn in decerebrate animals. Thus, if the head is turned to one

[1] Minkowski, M. Sur les mouvements, les réflexes et les réactions musculaires du fœtus humain de 2 à 5 mois et leurs relations avec le système nerveux fœtal. *Rev. neurol.*, 1921, 37, 1105–1235.

So pronounced are the spontaneous movements of the fetus by the fifth month that they are easily sensed by pregnant women, and shortly thereafter may be seen as deformations of the abdominal wall.

[2] By the fifth prenatal month the 10 billion or more cells of the nervous system have differentiated and, although they have not achieved their full development, the full quota of cells is already present.

side there is frequently a movement of the arm, sometimes on that side, sometimes on the opposite. Again, the younger fetuses show a great deal of variability, and as older fetuses are observed there is a typical increase in definiteness, until, as in the neonate, the typical supine posture shows the tonic[1] neck reflex wherein head and trunk rotate to one side, and the opposite arm flexes so as to bring the hand near the head.

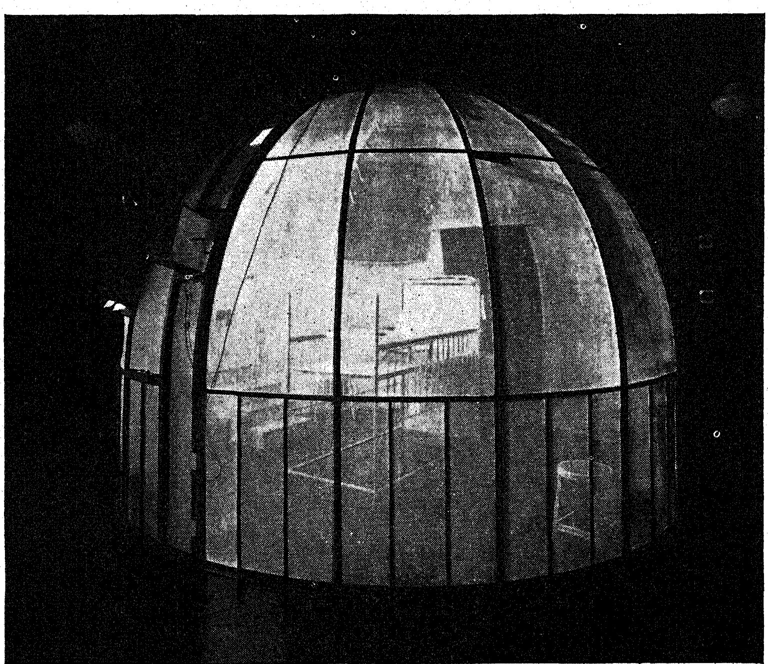

FIG. 52.—Observation dome. (*From Arnold Gesell and Helen Thompson. Infant behavior, p. 27. New York: McGraw-Hill,* 1934.)

One of the oft-noted responses of the newborn child, the grasping reflex, has been present since the 26th prenatal week. Initiated by a tactile stimulus to the palm of the hand, it has a tonic character; the child can grasp but does not easily release the clasp. The skin surface is generally sensitive, although apparently the sensitivity is greatest at the head end and decreases gradually along the body axis. Pupillary reflexes indicate that the optic tracts are

[1] Tonic, since they tend to persist as long as the muscles and skin of the neck area are stretched by the turning of the head.

ready to function in the second half of the gestation period, and the presence of taste buds and differential responses to sweet and sour demonstrate the presence of taste. There is some doubt as to the presence of pain, and the premature child appears to be deaf to ordinary sounds. There is some evidence of a rudimentary tactual localization. Gesell and Thompson observe: "We have seen a prematurely born infant with a mildly infected eye bring his tiny fist unerringly to the focus of irritation. Such accuracy of aim signifies a form of localization."[1]

For the most part the receptive functions will be limited during this period. Proprioceptive impulses and tactual stimulation must dominate.[2] Just how important the receptive functions are in regulating the course of development and in contributing to the patterns which emerge in the neonate no one can at present state. Where each movement results in a characteristic stream of stimulation from the kinesthetic, vestibular, and tactile receptors, it would seem that such regularly recurring and characteristic streams must etch their influence upon the course of development, so that one could speak of exercise, or practice, altering the course of development. But at the moment we must confess ignorance in the matter. There are some reasons for preferring the term "maturation," as a description of the changes at this point too. The fact that the fetus, even more than the neonate, spends most of his time in quiescence (sleeping?) and the further fact that the stages of development noted by Minkowski, in the early months, yield responses which are not disturbed by removal of the cerebral cortex, the *corpora striata*, and a large portion of the thalamus, argue that the development is primarily a growth process and that, if the effects of action record their influence, it is by other means than that which occurs in ordinary learning, where the cortex so definitely participates.[3] The restricted field of stimulation also suggests that whatever conditioning may take place will be within the field of the child's own postures and can scarcely prepare anticipatory adjustments to the external field of objects into which he is later born.

[1] Gesell, A., and Thompson, H. *Infant behavior*, p. 280. New York: McGraw-Hill, 1934.

[2] Receptor spindles embedded in striped muscles and tendons are reported as early as the 16th week.

[3] Minkowski, M. Precocious movements, reflexes and muscular reactions of the human foetus and their relations to the foetal nervous and muscular system. *Schweiz. med. Wschr.*, 1922, 29, 721, 751. Trans. by Heinrich Klüver.

One can understand, therefore, the tendency to interpret the development of the postnatal weeks as a continuance of this same maturational process. If the development of the 40 prenatal weeks is ascribed to growth factors, and if the bones, muscles, and sense organs—as well as the neural structures—of the neonate are still physiologically and anatomically immature, what is more natural than to see the subsequent unfolding of behavior as a continuation of this same maturation process. Thus we find Gesell and Thompson laying down as the ABC of "developmental diagnosis" the principles that:

A. The growth characteristics of the infant are primarily determined by hereditary and constitutional factors which undergo their basic organization in the uterine period.

B. These factors do not operate independently of postnatal environmental influences, social and physical, but they determine the direction and scope of such influences.

C. Maturational factors impart a characteristic trend, tempo, and general configuration to the early behavior patterning of the individual.[1]

In short, these investigators believe that it is possible to demonstrate an order and a plan in the early development of the child that no stretch of the imagination can attribute to any regular environmental constellations. Since their normative study affords one of the most extensive explorations of infant behavior yet undertaken, it behooves us to give some attention to their findings.[2]

The Neonate.—Before attempting to sketch the development of the infant it may be well to summarize the findings of numerous investigators[3] who have observed the newborn child.

[1] Gesell, A., and Thompson, H. *Infant behavior*, p. 326. New York: McGraw-Hill, 1934.

[2] The experimenters endeavored to secure a representative sampling and to this end selected children of native-born parents of middle-class status in respect to occupation, schooling, etc.; 107 subjects, 58 girls, and 49 boys, were studied, many repeatedly, and in all there were 524 examinations. An extended series of tests were devised, calculated to bring out the stages in development of postural behavior, locomotion, perceptual behavior, prehension, adaptive behavior (manipulative, constructive, learning), language behavior, and social behavior. Cinematographic and stenographic records were taken in addition to home records and histories of their cases. In addition to the films there were 5,564 pages of typewritten records. Examinations extended from the 4th to the 56th week.

[3] Cf. Pratt, K. C. The neonate, Chap. 3, *Handbook of child psychology*. Ed. by C. Murchison. Worcester: Clark Univ. Press, 1932.

Taking the most general view first, one would describe the neonate's behavior as random, chaotic, unintelligent, unsynchronized, uncoordinated. In spite of isolated patterns that are neatly adaptive, as, for example, the nursing reflex, the child is quite helpless, unable to lift its head or pursue a rapidly moving stimulus. Its movements are relatively slow and tend toward tetanus, and its sensory thresholds are relatively high. Thus, the infant will sleep through daytime noises that later will startle it into wakefulness. Of all creatures the human neonate is most helpless and dependent, responding to the immediate and pressing stimulus in brief segments of action, without anticipations, in planless and incoherent fashion. Many of its ceaseless movements are best described as spontaneous, or impulsive, for they are correlated with no visible external events. Thus one notes such reactions as yawning, rhythmic contractions of the eyelids (independent and uncoordinated), eye movements (equally independent and unrelated to vision), frowning, dilation and partial closure of nostrils, rhythmic mouthing movements, tongue protrusion, turning head back and forth, tears, vocalization, movements of foot and leg, play of the toes, vermicular rotating movements of the hand, independent finger movements, movements of the hand to the mouth and retraction, erection of penis. The receptors of the skin and mucous surfaces are notably sensitive, and in many cases the reactions elicited are both characteristic and adaptive, forming the roots of later adjustments of approach, rejection, withdrawal. Thus one notes:

Stimulus	Response
$AgNO_3$ drops in eye	Blink, cry, turning of head
Massive touch, back	Cry, contraction of extremities
Light touch, nostril	Sneeze
Heavy touch, nostril	Extremities stiffen, gross postural adjustment
Light touch, sole of foot	Babinski reflex, fanlike spreading and retraction of toes (variable)
Heavy touch, sole of foot	Withdrawal movement of stimulated leg, sometimes accompanied by movement of contralateral leg and arm
Blow on patellar tendon	Knee jerk
Light touch, palm of hand	Grasping movement which resists withdrawal
Touch, mouth area	Opening of mouth and sucking movements. If the child has just been fed, the same stimulus produces either indifference or aversion of head

Stimulus	Response
Touch, throat	Cough
Touch, cheek.	Head movements, and if combined with hunger and subsequent mouth contact, nursing movements
Touch, area around eyes.	Blink
Light touch, chin and mouth area. .	Smile
Removal of clothing.	Raising arms, arching back, stretching
Noxious stimulus.	Cry (and occasionally indications of primitive localizations are reported—otherwise diffuse movements)
Warmth (*e.g.*, warm bath). . . .	General relaxation
Cold	Diffuse muscular activity, cry

That the eyes are functional at birth is shown by the pupillary contraction to light (which is bilateral, although the stimulus may affect but one eye) and by the tendency to fixate a bright, stationary portion of the field. Following movements are rare and usually show defective coordination between the two eyes, this latter fact frequently disconcerting the uninitiated mother who anticipates strabismus. The general unresponsiveness to rapid changes in the visual field is shown in the infant's failure to blink in response to an approaching object.[1]

Differential responses to taste stimuli have been noted, although the frequencies noted by Peterson and Rainey as a result of testing some thousand infants do not suggest that this sense is notably developed. The grimaces and retching noted in connection with salt, bitter, sour, incline one to say that already this constitutes an "unpleasant" group; but it should be noted that the salt stimulus induced "contented suckling" in 503 of their subjects. Olfactory stimuli of an unpleasant character have been found to inhibit nursing movements.

Response	Stimulus			
	Sweet	Salt	Bitter	Sour
Contented suckling.	747	503	31	136
Discomfort reaction.	37	295	780	659

[1] Watson reports that the blink in response to moving visual stimulus does not appear until between the 75th and the 120th day.

The auditory receptors are less effective regulators of behavior.[1] If the child is awake, a loud sound will produce a startle reaction; if he is asleep, it may easily pass without effect. In general, one would describe a light touch as more effective than a loud sound. The startle reaction is diffuse and does not seem to be adapted to the sound source. Voices, words, are, of course, not differentiated from other noises, and the crying of other children does not induce sympathetic crying responses.[2]

Other general conditions, frequently a combination of both external and intraorganic states also contribute to the infant's repertory of behavior. To the diffuse combination of vestibular, tactual, and other intraorganic stimuli produced by a rapid lowering, the child gasps, throws up its arms, and cries. Restraining his movements by holding the head or extremities may produce diffuse patterns of flexion and extension which are easily interpreted as "struggling," although in so describing them we read an adult meaning and significance into an altogether diffuse pattern. Internal conditions, contractions and distentions of the gastrointestinal tract (as, *e.g.*, the cramps of colic), will produce crying, restlessness, and spasmodic muscular contractions—again of diffuse nature. Hunger, thirst, cold, visceral pain, thus provide internal "disturbers" whose presence contrives to lend a spontaneity and variability to the infant's behavior and to make its activity somewhat independent of external initiating stimuli. Sudden changes of any sort tend to produce the startle response. Thus Gesell describes the infant who, in the first days of his life cried as soon as he was picked up, and ceased to cry when he was allowed to rest quietly; two weeks later he cried when he was in his crib and stopped crying when picked up. This one example should serve to remind us that a network of anticipations—enforced by the round of routine activities connected with feeding, bathing, dressing, sleeping, etc.—will overlay these "original" reflexes, altering, combining, and sometimes reversing them, chaining them into series headed toward more and more distant goals. This network of anticipations is established side by side with the

[1] Flechsig, the anatomist, reports that the cerebral tracts mediating the auditory impulses show the lowest development at birth, corresponding to the retardation in function.

[2] Miss Blanton did not observe this sympathetic crying in any of her subjects under 15 days, although she made careful tests with phonographic recordings. Blanton, M. G. Behavior of the human infant during the first thirty days of life. *Psychol. Rev.*, 1917, 24, 456–483.

completion of that internal neural framework and parallel to a strengthening of bone and muscle and the maturing of auditory and visual receptors.

Postural Changes in the First Year.[1]—For a dozen weeks, so far as general bodily posture goes, the child comes very near to that hypothetical one-dimensional animal. Supine or prone, he cannot lift his head, nor can he—until the end of this period—so much as roll his pelvis or turn over on his side. The characteristic position portrays the tonic neck reflex, which has continued from the uterine stage, and waking or sleeping the child is likely to lie in this characteristic head-trunk-arm position (*i.e.*, with the head turned to one side facing an extended arm and with the opposite arm flexed so as to bring the hand near the head). By twelve weeks he may rear his head when placed in the prone position, and may support part of his weight on his forearms, but there is no suggestion of a crawl as yet. Even if held erect or in sitting posture, his neck muscles will not support his head. Held in standing position, his legs do not thrust against the floor, nor is the jumping and alternate thrusting of the legs ready to appear.

These earliest patterns are characterized by the weakness of the muscles, and by their stereotyped character involving the whole organism and permitting but little variation. By the second quarter the muscles grow strong enough so that, placed prone, he can lift head and chest from the surface, supporting this portion of his weight on his forearms. Held in a sitting posture, his head is erect and he is able to support himself for a moment by leaning forward and using hand and arm as stabilizer. Although he does not crawl, when held erect he does thrust his legs against the support, and thus shows that he is nearer locomotion. His supine postures are freer, and more variable; the head turns from side to side, the body rolls to the side, and the hands can be brought together and thrust vertically as well as laterally.

By the third quarter the infant has advanced so far along the road from supine to erect posture that he is able to sit, unaided, for a few minutes, and if leaning forward can erect himself. He supports his weight if held in a standing position, and rises on his toes; but it is not until the end of the fourth quarter that he is able to pull himself

[1] The description and normative values which follow are derived from Gesell and Thompson's *Infant behavior*. See especially their summary, Chap. 4, The ontogenetic patterning of behavior.

to his feet and take steps while still supported. By the thirtieth week he is sitting erect, and at fourteen months he may be able to walk independently. The progressive unfolding of the erect walking posture reminds one of the cephalocaudal rule which holds for kit-

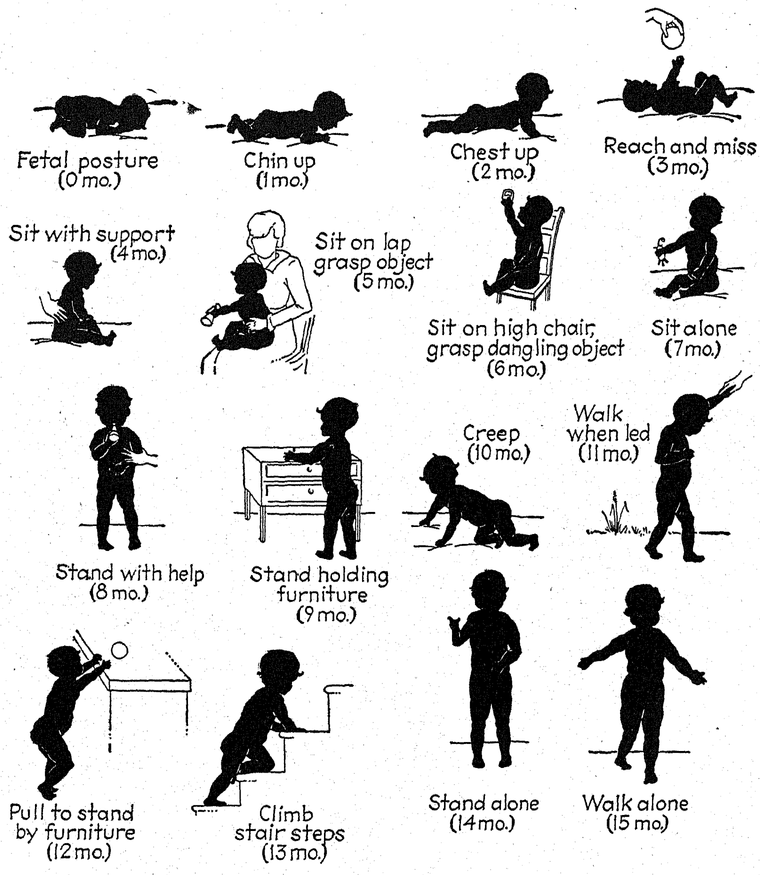

FIG. 53.—The development of postures. (*From Mary Shirley. The first two years; a study of twenty-five babies*, Vol. II. *Minneapolis: Univ. Minnesota Press*, 1933. *By permission of the publishers.*)

tens, opossums, and other mammals which have been studied. Instead of building the posture from the ground up, nature first adjusts the head and upper extremities, and the trunk and lower limbs follow. The fact that this development follows an order which parallels an order of neurological development (established by

anatomical and histological studies in many mammals) and that it follows a rather definite time schedule lends support to the maturational interpretation which Gesell and Thompson give their data. There is also the fact that the new developmental levels frequently demand the *abandonment* of the postures of the preceding level, rather than their *fixation*. The explosive contraction of both limbs which begins the creeping stage (and which leads to a backward "progression") is abandoned for the alternate contractions of true creeping, and the head-trunk-limb patterns of the all-fours method of progression is abandoned when the upright posture is fully attained. The infant is thus as busy "growing out of" patterns as he is in stereotyping certain elements. Both processes are undoubtedly at work.

Development of Manipulation and Perception.—If the posture of the neonate represents a unity in one respect, binding head, trunk, and extremities together (as in the tonic neck reflex), in another respect it separates the parts. Eye, hand, and mouth, for example, are separated by this posture. The lighted window which holds the eyes does not initiate grasping or mouthing. The nipple that initiates nursing movements does not bring about fixation or grasping. And the tactual stimulus to the palm initiates an isolated grasp which is disconnected from an appropriating mouth or fixating eye. His brief visual pursuits lapse easily into strabismus, so loose is the tie between the two eyes, and for the most part he stares without fixating, his few fixations being directed to large stationary or slowly moving masses and pursuits. Before the year is half out all this is changed and the infant that is sitting erect will seize, inspect, and carry to his mouth the objects that lie within his reach. Here, again, the head end seems to lead, for he is "appropriating" and anticipating by eye and mouth before the hand is ready to serve as manipulator and conveyor. By eight weeks his stare has changed to a roving inspection and pursuit, and, if the object vanishes, something akin to searching; and the brightening or sobering of his facial expression shows the development of discriminations and anticipations in the social field. Somewhere between the eighth and the sixteenth week he shows clear signs of anticipating feeding on sight of food. It would appear that the roving eye "pursues and captures" the hand, and by twelve weeks he may be seen giving sustained attention to his hand. In one respect it is not correct to speak of the eye as leading in this process, for a more or less successful

grasp has been there from the start, but it has had a rather limited sort of usefulness, confined as it was to the adjacent tactual stimulus. From the start the hand moves through the visual field. Lying supine with arm extended and head averted in the same direction, any movement must make its record in the visual field, and as visual pursuit develops, eye and hand will gradually merge so that coordinate adjustments are established. By twenty-four weeks he follows the visual cue to reach for and grasp an object placed before him; and as a prompt sequel it is conveyed to his mouth.

It is interesting to note that the unfolding of the visual pursuit pattern follows a definite and ordered plan. In an earlier study, M. C. Jones[1] showed that pursuit was shown first in the horizontal, then in the vertical, and then in a circular direction. Using a dimmed flashlight moving at roughly 6 in. per second, and repeating five times if necessary, she tested the children in the New York City Health Department's welfare clinics and obtained norms for the appearance of the coordinated pursuit.

Coordination	Number of cases	Age (days) at which 50 per cent show the pattern
Horizontal pursuit	312	58
Vertical pursuit. . . .	283	65
Circular pursuit.	272	78

The development of grasping during the second half of the first year is another interesting illustration of progressive individuation. The main movements, starting with a flipperlike sweep of the arm, are there before the elbow-wrist-finger refinements are superimposed; and the whole fist is crudely active before thumb and index finger opposition (thirty-six weeks) becomes differentiated. The complete poking, fingering, and pincerlike grasp demanded by finer objects has to wait for the fourth quarter (forty to forty-two weeks). Even so, the development of manipulative coordinations to a level so near to that of the adult within the second half year is rapid enough.[2]

[1] Jones, M. C. The development of early behavior patterns in young children *Ped. Sem.*, 1926, 33, 537–585.

[2] The experimenters, Gesell and Thompson, comment on this development: "He must be under strong impulsions to reach that level, for, although he will sometimes take recourse to primitive methods of grasp and approach to secure a

Perceiving, grasping, manipulating, are all intimately tied up with the development of posture. Like the wobbly chick a few hours out of the shell, whose visual-motor pecking responses lacked accuracy and did not improve with practice, the perceptual-manipulative skills of the child cannot grow more rapidly than the supporting head-trunk postures. With bobbing head the visual field must pitch and toss like the target before the sights of the marksman on a wave-tossed boat; and until the posture is stabilized, accurate pursuits and "expectancies" cannot emerge from the chaos of explosive contractions and compensatory reflexes. But, as in the case of hand and eye, parallel sequences emerge, synergy replaces the incoordinated and poorly timed series of contractions. The isolated eddies merge and the stream of behavior begins to flow in definite pattern. Dressing, bathing, feeding, toilet, sleeping, and the whole repetitious sequence of environmental stimuli, enforce rhythms of behavior, and the earlier items in the series induce anticipatory adjustments, preparing for the stimuli-to-come. Thus the experimenters observed that within from six to eight weeks the sobering and brightening of the infant's face showed that he had "anticipations" with respect to persons and faces, and by twelve weeks the majority of the infant subjects were credited with "knowing" their mothers. So, too, when the twenty-eight-week-old child is credited with inverting his hand in making an approach to the bell, we can see an "anticipatory adjustment" which must have grown out of his previous visual pursuits, graspings, etc. The ordering of a world which can be perceived, the emergence of meanings, discriminations, is thus seen to be a part of the postural-manipulative development. Sensitivity and motility develop side by side; in fact, since we cannot get within any "child's mind" at this point, to say that the child perceives an object can have no meaning other than that he is seen to make a

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coveted object, it is more characteristic for him to perseveringly employ a developmental innovation in advanced method even at the expense of failure. Immediate efficiency does not seem to be a rule of developmental economy."—Gesell and Thompson, *Infant behavior*, p. 279.

This observation seems clearly headed against any "learning" interpretation of this development. It seems to the experimenters that the progressive unfolding of the patterns is a matter of growth headed toward a biologically determined goal, and takes place in spite of the successes attained at the lower stages, successes which cannot "stamp in" or fixate the earlier coordinations. They seem to hint, in effect, that this progressive unfolding of prehension takes place *in spite of* rather than *because of* the learning process.

discriminative and anticipatory adjustment to that object. There is no other criterion. Hence the progression from the crude full-arm "banging" to the delicate poking of a pellet with the index finger or the change of anticipations (as in the motor inversion of the hand for the bell handle or in the brightening of the face for mother and the sobering before strangers) form the sole evidence of the early development of perception.

Progressive Individuation: from Gross to Fine.—As in the case of prehension, other adaptive responses follow the order from gross to fine adjustment. Sometimes the main lines are laid down in the crudest fashion and a "social attitude" is evidenced before mediating skills have been established. Thus the observers note: "The specific adaptive responses to a situation may be inferior to the underlying social attitude of the infant. Social orientation on an affective plane may be slightly in advance of his overt social acts. For example, his responsive behavior in the ball play situation at 44 weeks is very rudimentary. No real ball play can be elicited, and yet the infant looks regardfully in the direction of the examiner and shows pleasurable reactions which indicate that on an emotional level at least the infant is joining in the game with enjoyment. Full motor participation will complete the cycle of his adjustment. Such is the general mechanism of his social development throughout the first year of his life."

One is reminded of the way in which later "goals" accelerate and motivate the acquisition of new skills. The boy who wants to play ball with his fellows before he can throw or bat, or who wants to fish before he can thread a worm on a hook, is in a position like that of the infant. Main lines are laid down because the stimulating environment evokes persistent postures, and in time the parts fall in line. The "progressive individuation" of which the experimenters (following Coghill) speak arises as the details of the complete pattern are filled in. The excited breathing, cries, and flailing arms of the infant provide the raw materials which repeated stimulation progressively refines. Sometimes the "main lines" seem to the casual observer to involve most of the musculature and to be completely indefinite and random, so far are they from the goal. Yet however random and plastic they may be at the beginning, a progressive definition occurs. We saw, earlier, in the stair-climbing experiment with the twins, that the approach to the stairs from the creeping level laid down a main line of posture around which the stair-

climbing movements were grouped, and so influenced the patterns achieved that details of the pattern persisted even after the subject had attained the walking coordination. So, too, there is a head and eye versatility which establishes a postural line before the hand falls in step, and the head-eyes-trunk-hands are ready to manipulate the object-at-a-distance before creeping, crawling, and walking are able to provide the means of transportation necessary to bring it within range. Thus, at each stage the preceding matrix of habit and growth provides the main lines around which subsequent coordinations are grouped. If the Gesell and Thompson study succeeds better in sketching these main lines, for the early months, than in untangling the skeins of conditioning and growth, it provides evidence that the child psychologist, like his subject, must proceed by a method of successive approximations and that the full and "individuated" account of this development may be expected to ripen in time.

Social Development.—Socially, the development of the infant parallels the account of posture, prehension, and perception already given. His fixations of faces are as fleeting as those directed toward moving lights, in the early days, and as has been indicated, it is a matter of weeks before he begins to respond as a person. His "knowing" of his mother, with which the experimenters credit a majority of their subjects by 12 weeks, must consist in a fusion of expectations vaguely emerging from the thousand contacts connected with nursing, bathing, expressions of affection, etc. The process of discrimination is shown in that the child of 12 weeks ceases to "accept" strangers on the same footing. His reaction to persons up to this time has been as undiscriminating as it has been "massive" and crude, in pattern; but by the thirty-second week less than half the subjects will accept the stranger. But one must note that the process of change is slow, and that there are wide individual variations. In fact, one would expect wide variations in this field, not only because of individual differences in hereditary make-up, but because of differences in treatment, in amount of handling, in the number of persons concerned in the care of the child, etc. Social environments will vary much more widely than the influence of gravity and a hard supporting surface, so that one would expect to find wider variations in the infant's reactions to social stimuli than in his acquisition of basic postures and prehension. Some of the Gesell and Thompson items show this variability.

TABLE 3.—RELATIONSHIP BETWEEN AGE AND PERFORMANCE AS REVEALED BY REPRESENTATIVE ITEMS IN THE GESELL AND THOMPSON STUDY

Behavior items	Age in weeks											
	12	16	20	24	28	32	36	40	44	48	52	56
Accepts strangers	100	80	61	52	59	41	39	39	26	18	18	14
Withdraws from strangers	0	19	8	24	16	47	42	19	48	44	30	9
Adjusts to words		0	8	12	16	47	68	75	94	82	89	73
Responds to "bye-bye"		0	3	3	3	13	35	53	65	38	59	27
Adjusts to commands		0	0	0	3	22	23	31	55	56	73	50
Responds to inhibitory words		0	0	0	3	25	23	28	45	44	52	23
Responds to "So big"		0	0	0	0	6	7	8	26	18	34	0
Elicits attention		0	0	0	0	9	16	14	26	27	53	50
Plays pat-a-cake		0	0	3	6	19	23	25	42	27	50	9
Plays peek-a-boo		0	6	6	0	9	13	11	13	9	25	9
Has regular toilet training	3	12	35	48	47	59	71	83	86	90	96	90
Says one word or more				0	7	12	21	34	69	77	88	95

The numbers in the column refer to the percentages of subjects "passing" the test item.

Of primary importance in the social adjustment of the individual, language reactions make their appearance during the first year. In this field the infant's responses to words far outnumber his language productions. By forty-four weeks he is adjusting to simple commands, and at the age of a year obeying inhibitory commands. For the first half year his language productions consist mainly in a rehearsal of the syllable units which he will later use in speech. As a matter of fact, it is probable that by four months he has worked through all the combinations, including some which he will never use in his native tongue. As his facility in producing the syllables grows he is found repeating them, and by the end of the first year he is ready to begin copying the verbal patterns offered to him. By the fifty-sixth week 95 per cent of the Gesell and Thompson subjects were credited with one word or more.

In a similar fashion the child's perceptions, discriminations, and expectations with respect to persons grow before his attempt to control them. It is some time after he shows that he knows his mother, and begins to discriminate between her and strangers, that he shows evidence of more or less continuous adjustment to the presence of people. The experimenters describe the child of the third quarter as more or less "self-contained," more interested in the appropriation and exploitation of single objects than in his

relationship to the human environment. But in the fourth quarter he is paying close attention to gestures and "demonstrations"; in fact, he begins to use gestures and demonstrations to further his own ends. He begins to be interested in the effect of his actions upon the audience, repeats performances that are laughed at, and clearly does a variety of things to secure attention.[1] The order in which the social patterns develop, first the receptive and then the expressive or controlling, suggest not merely that the social environment molds the individual and serves to control his responses, but that it is somehow incorporated, literally, so that his own inner world of expectancies (a very rough approximation of the world about him, to be sure) comes to replace the immediate and pressing external stimulus which was so important in initiating the action at the start. From an almost mechanical and passive subject he is transformed into an active agent, not only anticipating changes-to-come, but exercising his abilities in speeding them on their way or avoiding them in advance, or preventing their occurrence. If he is at first shaped by his world, before the year is out he has embarked on the business of re-creating and rearranging that same world.

Summary.—This attempt to establish developmental norms for the human infant presents a host of problems—and a hope. Among its most promising features is the possibility that it may lead to the detection and diagnosis of developmental defects at an early age, and that with an increasing understanding of deviations correctional measures may be taken to ensure improvement. But as yet the norms present more problems than solutions. A glance at the data will suffice to show the nature of the problem. For example, 3 per cent of the subjects are able to push themselves upward and backward to a sitting posture as early as the 32d week; but there are 6 per cent who still do not do this on the 52d week. Again, 3 per cent attain a standing posture independently as early as the thirty-sixth week, but there are 55 per cent who do achieve this pattern as late as the fifty-sixth week. Just what age level shall we set for these patterns, and how shall we account for the deviations? The deviations are the more remarkable when we remember that the experimenters selected their subjects from a rather narrow social stratum. In all probability a wider sampling would have yielded even greater deviation. Since the norm can have only a statistical

[1] Gesell and Thompson noted that "If necessary he may even cough or clear his throat to elicit attention."

validity, and since the deviations are described but not explained by a merely normative (as against an experimental) approach, and since, furthermore, the number of cases upon which each age-level figure is founded is altogether too small to have great reliability, this pioneer study can be said to have raised a host of problems and to have solved none. While the authors are inclined to stress the intrinsic, or maturational, regulation of development, proof of their interpretation must await the completion of many extended studies. The experimenters are frank to confess this fact and comment upon the number of factors which conceivably influence the developmental rate.

Among the items which help to produce variability in performance are those connected with the prenatal period. The full extent of their influence cannot be estimated any more than the physician can determine exactly the age of the child at birth. If age from the time of conception is the important fact in estimating maturity, and if deviations in the gestation period of as much as 6 weeks (before or after the average term of 40 weeks) are common, we cannot expect even those items which are completely dependent upon hereditary factors to yield sharply defined norms when age is commonly reckoned from the date of birth. Add to this the undoubted fact that prenatal nutrition, the health of the mother and the possible disturbance of blood-stream toxins, and the traumatic complications which often attend birth, all enter into the determination of the growth complex, and we can see reasons both for variability in the norms and for hesitation in lumping these variations in the "inherited" category. Endocrine disturbances in either mother or child will alter the process, and if some of the endocrine variations are attributable to the genes, others will flow from dietary or other extrinsic causes.

Diseases will etch their influence upon the infant's performance through both physiological and psychological channels. The peevishness which follows illness may indicate physiological aftereffects, or the result of changed methods of handling, the perseveration of habits developed during illness. And just as the method of handling in the home must produce temperamental differences, so the method of administering the examination may produce differences in the child's performance. The miracle is that, through this welter of possible causes for deviation, anything approximating a definite series of norms can be obtained. Looking at these norms,

and the orderly progression of changes, the maturationist is likely to assert that the extrinsic factors merely produce minor fluctuations on a growth curve that is fundamentally an affair of internal regulation. But the minor fluctuations are, after all, not so negligible. When the gap between the precocious and the retarded infant, as in sitting erect, extends over 20 weeks, we cannot speak of minor fluctuations; and, in view of the number of possible causes, we cannot rest content with any simple generalization when there is no experimental basis to support it.

Among other things, we should like to know whether the precocity at four months is likely to be shown again at a year, and at six years. There are a number of studies which suggest that infantile precocity or retardation does tend to be a fair index of later development. Gesell has followed cases, of both superior and inferior rates of growth, through the first 24 months, and has found them quite constant.[1] Other studies indicate that on the average the brighter children are apt, not only to learn to talk earlier, but to walk[2] and to acquire their teeth at an earlier age also.

However, it is one thing to say that, on the average, intelligence is associated with the age at which the child learns to walk and another to use the walking age as an index of intelligence and a basis for prediction of future mental development. Just as calcium metabolism affects teeth formation, so that the latter factor may be used as an index of either dietary or constitutional defect, so the walking age may be an index of either intrinsic or extrinsic factor, in any individual case. That no simple relationship holds is obvious, for we should be forced to predict a much higher intelligence for the guinea pig and the rat, or the infant ape Gua, than could be attained by any human child, if it were so. It is probably true that precocious development is general, as a rule, and that just as the infant's vital indices and early postures show precocity, so his capacities, his rate of habit formation, his ultimate intelligence, will show precocity, on the average and within the species, where distorting environmental factors can be ruled out. But such generaliza-

[1] Gesell, A. *Mental growth of the pre-school child.* New York: Macmillan, 1925.

[2] Mead reports that the median feeble-minded child walked at 21.6 months and talked at 34.44 months, whereas the "normal" child walked at 13.54 months and talked at 15.8 months. Mead, C. D. The relations of general intelligence to certain mental and physical traits. *Teach. Coll. Contr. Educ.*, 1916. No. 76.

tions have to be so hedged about with qualifications that one might as well confess at once that any individual deviation from an established norm presents a problem, not a diagnosis. Neither can one offer much more than a statistically defined "probability" in the way of prediction.

That generalizations of this type do not carry over, as between species, is obvious. In fact, one would be nearer the truth to state the opposite, namely, that intelligence seems to be associated with a slower developmental cycle, rather than with the more rapid one. The insects, rodents, and all the simpler forms which have such limited developmental goals may cover, in hours, what it takes a child years to traverse. Even the Macacus rhesus monkey, nearer to man, is ready to walk in 12 days in a manner superior to that of the child of 12 months.

Development, too, is frequently saltatory.[1] A child that has been keeping his linguistic accomplishments to himself in such a way as to worry a solicitous family may suddenly show a burst of new accomplishments which place him on his proper level, and minor illnesses will etch their effects in behavior as they do upon the weight curve. If these latter cases are not typical ones, they must at least be allowed for, and developmental diagnosis will have to depend upon a series of observations rather than upon a single segment of behavior. But in spite of the unsolved problems, and serious limitations which characterize the present status of developmental studies, the pioneering that has been done in this direction promises a rich harvest. Just as the death rate of the first six years is steadily giving way before the advances of medical science, it is possible that we shall be able to lift the level of human accomplishments by removing developmental hazards before their effects are too deeply ingrained and the psychological mischief done.

Capacities: General and Specific; Native and Acquired

Every new mechanical appliance affords a test of capacity. The recent developments in aircraft and radio have found hundreds of skilled performers. So, too, the violin and piano challenge the organism's capacity. Of what does such capacity consist? In

[1] One of Shirley's cases, for example, showed actual retardation in postural and locomotor development until the 20th week, from which point on he progressed rapidly, becoming the most accelerated baby of the group. Shirley, M. M. *The first two years*, p. 110. Minneapolis: Univ. of Minnesota Press, 1931.

broadest terms it consists of the entire reaction equipment, both that which is inherited and that which has been acquired at the date the test is made. Nor is this complex totality easily analyzed into separate components which may be combined into a formula for a specific type of talent. The genius of one radio engineer may be composed of many elements not present in another; and one musician may have a finger span and speed of movement not matched in another whom the critics may agree has equal eminence. Even the most ardent geneticist will insist that there is no basis whatever for assuming a single gene for mechanical ability or for musical ability—that these complicated skills must rest, genetically, upon a combination of factors. The thing which makes genius so rare is that the particular combination is so unusual that it does not occur readily, and is not transmitted intact.[1]

Multiple Determination the Rule.—To complicate the problem, capacity is never a purely genetically determined affair. The discovery of radio transmission found those who were competently trained in physics and electrical engineering, and who possessed certain mechanical skills, to be in a position to exploit the new invention most successfully. Similarly the instruments which preceded the piano prepared the way for the new instrument, and those skills plus a fundamental training in music helped to compose the capacity for piano. The child's capacity to imitate speech sounds, at the age of a year, is no purely native affair, for there has been a year of practice of the basic syllable elements in the vocalization play of the infant. And as in the medicine-dropper-fed chicks of Miss Moseley, the preliminary training may result in negative capacities as well as in positive ones. A faulty start may introduce interfering habits so that one starts at a level below the zero of pure and unalloyed ignorance. If Aunt Polly does not succeed in "civilizing" Huckleberry Finn, we need not attribute

[1] As an illustration of the elusive character of these combinations, consider the attempts to reduce the successful sprinter's bodily measurements and vital indices to a formula. Although the hundred-yard dash represents a relatively simple type of genius, and although there is sufficient motivation in the matter—for what track coach would not wish to have the formula for selecting those worth training—no simple formula of the available measurements has been found. Apparently the only index of such skills that has any reliability is a sampling of the skill itself, and the most serious handicap to this procedure lies in the fact that such a measurement is always influenced by the level of training at which the sample is taken.

the boy's perversity to defective genes and insist that just as every animal likes its own ways, instinctively, so the "lower orders" of society prefer their own ways and transmit such preferences to their offspring. There has been a great deal of hasty (and sometimes shallow) reasoning concerning this problem of capacity[1] and a pseudo science which is dangerously convenient for all those apostles of reaction in the social and political fields has been created.

Inadequacy of the Early Studies.—The statement of the problem for man has to be made largely upon the basis of inference, rather than direct measurement or experiment. The span of time covered by human generations is so great and the complicating effects of varying environments (never controlled and seldom adequately analyzed) so confusing that the enormous literature on the subject of human heredity contains a mountain of speculation and few nuggets of fact. Galton, in his pioneering studies of British genius, could say that the sons of eminent men had one thousand times the chance of success possessed by the average son; but only the prejudices of a society which was convinced that "blood will tell" and which harbored an hereditary aristocracy could give the prejudicial basis for a "biological" interpretation of the facts. Similarly, the family studies of the Jukes, Nams, Kallikaks, and others, which have revealed long lines shot through with feeble-mindedness, degeneracy, criminality, alcoholism, etc., may give the sociologist and criminologist a kind of actuarial prediction, and thus introduce a semblance of order in the field of social phenomena; but like the normative studies of childhood, these studies yield descriptions but not explanations. And so lacking are these studies in scientific accuracy and completeness that no exercise of the scientific imagination can make up for the basic defects in the original data. Thus the study of the Kallikak family originates in a union (out of wedlock) between the Revolutionary war soldier, Martin Kallikak, and a "nameless feeble-minded girl." When accurate measures of intelligence were not available before the 1900's, how could a girl about whom so little was known that she had to remain nameless be diagnosed as feeble-minded? True, the family tree is spotted with feeble-mindedness (in the recent "measurable" years) with a frequency too great for chance, but who knows the full effect of an

[1] Goddard, H. H. *Human efficiency and levels of intelligence.* Princeton, 1920. Wiggam, A. *Fruit of the family tree.* Indianapolis: Bobbs-Merrill, 1926. McDougall, Wm. *Is America safe for democracy?* New York: Scribner, 1921.

atmosphere of debauchery, alcoholism, and crime upon the developing young Kallikaks, or of the role played by disease and infection, even in the prenatal months? And if the Edwards family, by contrast, produces a line of paragons of virtue and pillars of society, as a scientific study it possesses grave faults, for the record reports an altogether too small proportion of the living descendants. In short, while there is a vast literature dealing with the inheritance of human traits and capacities, much of it is scientifically worthless and smacks more of special pleading than of an unbiased search for the facts.[1]

The Logic of the Problem.—The student of heredity is likely to approach the problem of the inheritance of mental capacities with some such logic as this. Behavior is the functioning of organic structure. This structure, including every part of it (sense organs, nervous system, muscles, etc.), will vary from species to species and from individual to individual. These differences, moreover, are heritable. The pointer, the poodle, the race horse and draft horse, the tiger, the cat, all possess a behavior equipment and a set of capacities . . . why not men, and man? Now it is known that hair color, eye color, brachydactyly (short-fingered), hemophilia (bleeding), body build, sex, and numerous other items behave in general as gene-determined traits. And if Jesse Owens's legs and Caruso's throat, why not sprinting and musical ability? If these latter are founded upon more complicated (and rarer) combinations of the genes, are they any the less hereditary? Without falling into Lamarckianism, which maintains that even habits may be inherited, do not the well-attested studies of structural elements lay sufficient groundwork, at least for the inheritance of capacity, both general and specific?

[1] Recent developments in the science of mental measurement have done much to correct one of the faults of the older studies. Instead of depending upon hearsay evidence and the gossip of the oldest inhabitants in building up a family tree, the student of inheritance can use the more recent instruments. His measurements will not do away with the further task of experimental analysis, however, and since there have not been enough human generations to permit more definitive studies, little has been done beyond sketching the outlines of a solution. These outlines will be discussed again in a later chapter on intelligence and since there are special logical problems arising with these new measures, a detailed discussion of the results will be reserved until that time. The present discussion may be regarded merely as a sketch of the general outlines of the problem.

Now, while it is true that selective breeding experiments are not carried out on man, there is no reason to suppose that the genetic laws which hold for other mammals should suddenly cease to operate in this case. Consider the following facts:

Three groups of rats were reared in the same laboratory room until the age of 100 days and, up to that time, were not subjected to any taming influences whatever, beyond those necessitated by feeding and cleaning of cages. The groups consisted of 10 descendants of wild brown rats, 17 domestic albinos, and 70 half-breeds resulting from crossing with wild brown males and domestic albinos. When all had reached the age of 100 days they were removed from the home cages daily to be rated, under various experimental conditions, for degrees of wildness and savageness. The differences between means of the three groups on each of the ten days of rating were statistically significant. The sigmas of the distributions, however, were quite similar as to magnitude. Although one finds some overlapping of scores of wild and half-breeds and also of albinos and half-breeds, there is no overlapping at all between scores of albinos and the wild strain. On the whole, the obtained differences in temperamental traits are clean-cut and unequivocal. Moreover, they are such as any competent observer might be expected to obtain upon repeating the experiment. Therefore, although the experiment is by no means crucial for determining what specific intraorganic factors gave rise to the temperamental differences in the three strains, we are probably safe in assuming that the primary controls were hereditary.[1]

The hereditary character of such general traits is further borne out by experiments in which the fertilized eggs of brown rats were transplanted to the uterine tubes of albino mothers, thus equating all the prenatal factors which surrounded the albino offspring. But here, again, the expected wild brown rat traits appear.[2]

As for differences in the general capacity to learn, we scarcely need experimental evidence to convince us that genetic factors impose limits here, for the crudest observation convinces all of us of the existence of species differences in this respect. Nor will the isolation of strains, say of white rats, whose average learning rates are as definitely established as the temperamental differences

[1] Stone, C. P. *Handbook of experimental psychology*, p. 363. Ed. by C. Murchison. Worcester: Clark Univ. Press, 1934. Reprinted by permission of the publishers.

[2] Nicholas, J. S. Development of transplanted rat eggs. *Proc. Soc. exp. Biol., N. Y.*, 1933, 30, 1111–1113.

between brown and white varieties, do more than reaffirm what is to be expected. Further than this, the maturational studies have already suggested that within a single individual there is a curve of capacity, his age level determining rather definitely his ability to profit from experience and training.

Thus, corresponding to the outwardly visible differences in bodily build and general appearance there is a behavioral difference, and we may speak of capacities, both general and specific. Horses will differentiate into coach and carriage, draft and race horse, with capacities that match structure. Dogs will likewise evince capacities which correspond to the species.[1]

Endowment Sets Limits to Educability.—The strength of this general logic seems unassailable. It is when we come down to cases and attempt an analysis of specific skills or attempt to set up the actual ranges of original capacity (either general or specific) in the human species that we run aground. We have, for example, no valid measure of general capacity that is applicable to the various races and nations of men, that will not be complicated by the various cultural environments. Nor have we an analysis of such an ability as music that will enable us to select in advance those with musical capacity from the nonmusical. It is true that we can discover various "handicaps," such as tone deafness or absence of a sense of rhythm; but the presence of an accurate sense of pitch and of rhythm is no more a basis for musical training than it is for piano tuning or tap dancing. We can better discover those who will have difficulty in developing along certain lines than we can discover those who have concealed and undeveloped talents. The socially valuable skills

[1] Stockard believes that the endocrine glands provide the intermediary mechanism lying between gene and trait. He notes that, for example, when the wild, long-legged, erect, German shepherd is mated with the squat, bent-legged basset hound the short-legged hybrids (F_1) "all have the long drooping ears of the hound and never the erect ears of the shepherd, and the voice or bark is also more hound-like than shepherd-like. When these hybrid pups are reared by a sherpherd mother and have never seen a basset hound they will, when put on the field for the first time scent with their noses down and bark as they run, behaving as their hound father would do, acting in a manner entirely unlike the reactions of their shepherd mother with whom they have always associated. Thus their hunting instincts are as truly inherited as leg-lengths or hair color, being probably associated with acuteness of smell, and are not, in this case at least, developed as a conditioned reflex."—Stockard, C. R. *The physical basis of personality*, pp. 228–229. New York: Norton, 1931. Reprinted by permission of the publishers.

are, in fact, so complex and so much dependent upon a tradition and a training that one is inclined to be skeptical of the inheritance factor, save as it provides a mere potentiality, and one is inclined to suspect that such potentialities are rather widely held. There is no reason to believe that the physical organism of the Eskimos or the South African natives should not possess all the native qualities necessary for skilled violinists or laboratory technicians. That they do not possess them is in all probability solely a matter of their cultural inheritance. This line of reasoning leads logically to the further point, that instead of being the sort of thing that "will out"—favorable conditions or no—genius in these socially valuable actions is precisely the opposite sort of thing. It requires the most special fostering conditions. The original make-up may set limits or boundaries, may determine which lines are most difficult for the individual, and definitely preclude development along certain lines, but that it will burst forth, the environment notwithstanding, seems unlikely, to say the least. Only when we can make sure that environments are equated can we point to the differences between individuals as fundamentally affairs of inheritance. This being true, the application of genetic findings to social phenomena, to class and occupational differences, to the problem of crime, to special abilities, etc., is quite premature.

The Power of a Proximate Social Environment.—There is one situation in which the original equipment may serve to facilitate the establishment of a "drive," or major interest. Under human competitive arrangements, any type of learning which is congenial to or in line with one's set of capacities, and which therefore leads to a faster rate of progression than that enjoyed by one's competitors, will entail social rewards and satisfactions which will bring fresh interest and motivation to the task. Other things being equal, training on such congenial lines yields the largest increment of skill. But the "other things" constitute a by no means insignificant group of factors. Even with equivalent training and environment it is as much the relationship between one's own equipment and that of the particular few who are our proximate competitors as it is the relationship between training and true capacity which determines the satisfactions resulting in changed motivation. An impossible standard or ideal held up by unwise tutors may deflect the individual from the line congenial to his true make-up, and spurious success

may likewise motivate him in a direction that is counter to his basic capacities.

The importance of the shaping and directing factors looms large in this picture. At present they operate without much consideration of original capacities, and alas for the "science" of vocational guidance, psychology has little or nothing to offer in the way of measures of special "gifts." At the present time the most that can be said by way of guidance is whether or not the individual possesses the general ability to acquire a complex training and whether or not he has obvious defects which would make any given acquisition difficult or impossible. Thus, a youngster with a low I.Q. would be dissuaded from undertaking college training or the practice of medicine because it has been found that nine times out of ten college entrants with such low I.Q.'s fail before graduation, or that such I.Q.'s do not get through medical school. But as to measures of musical, mechanical, scientific, or other "talents"—in advance of the actual training of the skills—the psychologist is as yet quite unequipped. He could not go into the backward village and select the possessors of special talents.

It is even possible that the differences in physical capacity are so greatly outweighed by training factors that for all practical purposes one should forget the existence of special capacities. One would think, to watch the speedy tapping of the skilled typist, that sheer speed of movement is an important factor; but no measures of reaction time will reveal typing ability, nor does the most skilled typist ever approach the limit of repetition of simple movements. The coordination factor looms so large that the physical limits do not figure. Nor are painters as a class known to possess superior vision. It is rather their ability to translate the "seen" world into water colors or oils. In terms of their subject matter their discriminations will be sharper, to be sure; but that is as true of the Indian following a trail or the biologist peering through a microscope. In sheer visual acuity they will scarcely exceed the average. And those with markedly defective vision would be barred from microscopy as well as painting. In the light of these considerations, Watson's statement in his *Behaviorism* seems theoretically well grounded, even if a little rash, practically.

Give me a dozen healthy infants, well formed, and my own specified world to bring them up in and I'll guarantee to take any one at random and

train him to become any type of specialist I might select—doctor, lawyer, artist, merchant, chief and yes, even beggar-man and thief, regardless of his talents, peculiarities, tendencies, abilities, vocations, and race of his ancestors.[1]

Watson has protected himself in asking for healthy, well-formed infants, and one presumes that this means that neither in general capacity nor in special defects are there to be definite hindering factors. And while anyone who has brought up a family will note the temerity of the psychologist who guarantees to deliver talent on specification, since, in fact, there are so many events over which the individual has so little control, one can agree with the general emphasis on the shaping factors. Since the "normal" individual is a statistical fiction, and since each of us has his peculiar handicaps, the geneticist might accept the statement but insist that it applied only to a theoretically perfect group of specimens, and that for the actual existing population the genetically determined differences would, in fact, determine the actual achievements of doctor, lawyer, etc.

Concluding Remarks.—Even the general emphasis upon shaping factors has a questionable value in dealing with individuals. While in general one may feel that the complex socially valuable skills depend so much upon the educational, traditional, training factors that the genetic differences may be minimized, in individual cases these very factors may be all-important. What their precise role may be, especially in the present state of our knowledge—when satisfactory analyses of talents are lacking, is quite problematic. The clearest case can be made for a general capacity to profit from training, and we shall return to a more detailed analysis of this problem in our later chapter dealing with intelligence.[2]

[1] Watson, J. B. *Behaviorism*, p. 82. New York: People's Institute, 1925. Reprinted by permission of the publishers.

[2] It still remains true that a close blood tie to eminence is the best index to talent. Membership in the Bach family did carry with it a guarantee of musical interest and talent above the average. Even allowing for the omissions in the recorded descendants of Jonathan Edwards, there are too many socially valuable persons to be attributed to mere chance, and the number of times in which names are repeated in the *Encyclopaedia Britannica*—and family ties evidenced —is likewise an indication of something superior to chance relationship. This does not, of course, offer an explanation. The scientific imagination which finds a resemblance between the family charts and the charts of inheritance in Drosophila has run far beyond those cautious boundaries pegged out by supporting

The logic with which the student of heredity approaches the problem of capacity, stressing as he does the fact that behavior is a functioning of organic structure and emphasizing the heritable character of the latter, is correct enough—and yet it amounts to a half-truth. Behavior is also a function of the environment and diversities in the stimulating conditions may deflect the developmental curve, alter capacity, and shape special interests and skills. Moreover, in an organism in which the learning process plays so large a role as it does in the case of man the contribution of the genes must remain to a large extent polymorphous, in that it may figure in a variety of possible outcomes, the actual outcome of specialized gifts or defects depending upon the coexisting stimulating conditions. To argue that since "any mental characteristics, any feature of behavior, can be altered by a change in the genes of the individual" the genes can *produce* the behavior is to lapse from that common basis of agreement from which all profitable discussion of the question of heredity must begin, namely, that neither gene nor environment can give an adequate causal basis for behavior, when taken alone. Unless the reader supplies the necessary qualifications himself, the discussion of the role of the genes in H. S. Jenning's *Biological basis of human nature* will be found to bristle with items which betray the geneticist's bias.[1] For example:

> Further, diversity of gene combinations *brings about* [my italics] the differences, whatever they are, in the mentality and behavior of the two sexes. The female contains a certain set of genes in duplicate series, while the male has the same set in but a single series; from this result all the differences between the sexes, structural, physiological, mental . . .

or:

> The same kinds of differences between individuals can be *produced* [my italics] by diversity of genes and by diversity of environment. . . .

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facts. It thus seems possible to predict (roughly) where it is not possible to explain.

This importance of blood tie must be qualified, however. Although a greater proportion of mentally superior parents will produce mentally superior children (on any theory, environmental or hereditary), the greater *number* of superior children will come from mediocre parents. If superiority were solely a matter of genes, this would be true; but since the superior environment provided by superior parents is an undoubted factor, the number of superior individuals arising from mediocrity is less than genetic frequencies would lead us to suspect.

[1] Jennings, H. S. *Biological basis of human nature*, Chap. 8, esp. pp. 160 *ff*. New York: Norton, 1930. Reprinted by permission of the publishers.

A difference between two individuals consisting in the fact that one can speak French while the other cannot, or in the fact that one can play the piano while the other cannot, results *in many cases* [my italics] from the different instruction, training, or other experience undergone by the two.

The first of these examples reminds one of the nursery rhyme which attributed the loss of the battle to the horseshoe nail. Without the particular gene combination that produces the female, this particular specimen might not have had the womanly traits which we observe. True! And without the whole tradition of womanly virtues (*Kirche, Küche, Kinder*) and the economic subservience of women, she might have lacked them even possessing the female genetic endowment. In fact, the recent "emancipation" of women suggests that the genes are certainly not the sole determiners of womanly traits. Why should the geneticist use the terms "bring about" and "produce" if he has not joined the heredity-environment Locarno with tongue in cheek. And why should he say that whether one speaks German or French is determined "in many cases" by one's training? Is it not *always* the training factor which determines such matters?

Furthermore, if one is thinking in terms of a practical program of social reform and not in terms of a purely academic discussion, the environmental emphasis of a Watson is much nearer realization than emphasis upon heredity which characterizes the eugenicist. If one is interested in raising the level of human capacity and in releasing human talents, he must work through environmental arrangements. The curve of distribution of income, which is also a distribution of environments, cries aloud for correction. And if the eugenicist, foolishly disregarding the fact that he lacks the genetic knowledge or the power to control human matings, speaks of breeding a superior race, we can remind him that even the geneticist who thinks of feeble-mindedness as an affair of genes admits that 90 per cent of the feeble-minded must be born to normal parents, since it is one of those recessive characters. If a eugenicist-dictator were granted full power to control all matings, and if he were able to separate out the truly genetically determined brands of feeble-mindedness (from, say, those arising from toxic or traumatic events in early development) and eliminate through socialized medicine all the other types, it would take two thousand years to eliminate one-half of the feeble-mindedness present today.[1]

[1] Graubard, M. *Genetics and the social order.* New York: Tomorrow, 1936.

And until something is done to equate the environments of men, we shall never know to what an extent they are able to elevate or depress human capacity. Judging from some of the pronouncements of our popularizers of science, they would probably have explained the illiteracy of the mass of Russians in the czarist days as an evidence of the fact that the majority of the population had a defective native capacity, but a new regime has clearly demonstrated that the original capacity demanded by literacy was held very widely indeed. Until man constructs a social environment that is fit for capacity to develop in, the psychologist must be cautious in his description of the genetic endowment as a limiting factor. The social scientist who would explain our present stratified society in terms of differences in the genetic endowment of classes offers us those half-truths which may serve as rationalizations of an existing order: they are something less than science.

CHAPTER VI

EMOTION

A Functional Definition

It may help us to locate and define our problem if we consider, briefly, certain general aspects of human behavior. What is the role of emotion? From what other types of behavior are we to distinguish it?

A social psychologist writes, for example, "Man is always a feeling and emotive being. Only in a secondary way is he an intellectual, rational, and deliberative person."[1] Shall we say, following this author, that the emotions (fear, rage, love, disgust) are the *prime movers;* that our habits are formed in the service of these basically irrational forces, and that what we call reason (or deliberation) is at best a minor modification of the main pattern of behavior, a pattern rooted in our affective nature?

Now, it is true that all too often (especially when he moves in crowds) man seems to be swept to his decisions by gusts of emotion, and to regulate his life by his pulsebeat rather than by a law of reason. The sentiments which are organized around the flag, our native soil, our home, and our religious beliefs, flare into full-blown emotions at slight provocation. And it would seem that the successful crowd leader, who knows how to inflame men to action, depends more upon his knowledge of emotional "counters" than upon logic. It is not the cold logic of the Bryans, the Longs, and Coughlins, which makes them a menace to those who oppose them; the skill of their demagogy is of another sort.

When, for example, William Jennings Bryan went down to Tennessee to act for the prosecution in the famous Dayton case, he did not ask the jury to weigh the evidence for and against Darwin's conception of evolution. Rather, by playing upon their religious sentiments and old sectional feelings, he fanned the flame of anger and obscured the rational process. He called attention to "these northerners, foreigners, who have come down to call you *bigots,*

[1] Young, Kimball. *Social psychology*, p. 51. New York: Crofts, 1930.

yokels." He appealed to their religious attitudes, creating a picture of a "*conspiracy* among *atheists* and *agnostics* against the *Christian* religion." "Why," said he, "they have not the *honesty* to make the attack openly . . . Yet they would *rob* your children of their belief in immortality . . . and *drag man down* to a brute basis. Evolution is the center of *disease* and *death.*"

Whether we refer to our orator as "silver-tongued" or as a "demagogue" will depend somewhat upon our sympathy (or lack of sympathy) with his cause; but in any case we see his power as flowing from his command of emotion-producing language. And our propagandist likewise seeks to lead us up to the climax of action (and decision) by his skillful use of similar stimuli. His phrases, his slogans, his pictures, beat upon us, stirring forces within us that we but vaguely understand; our conscious, rational, deliberative nature seems like a frail and tiny bark swept along on the deeper tides of emotion. How else can we understand the way in which the peaceful Yankee farm hand leaves the plow to rush off to the muddy, shell-torn trenches of Flanders, inflamed with hate and ready to do battle? How else was he able to induce the peaceful German burgher to leave his beer garden, Muenchner, and Strauss waltzes, for Verdun?

To our contemporaries who do not share our impulses, our conduct seems irrational. The Jew-baiting of Hitler, his play upon the mysteries of "blood" and race, will seem to the outsider to offer a poor excuse for the acceptance by the German people of policies which steadily yield a lowering standard of living and lead inevitably to new insanities in the international field. Similarly, the religious devotee will be described as a fanatic by those who do not share his emotional reactions to the symbols of his faith. It would seem, therefore, that our conduct is judged as rational where our emotional experiences are shared by those who pass judgment. It seems, further, that our emotional reactions possess unusual force, for they both impel us to act and give something approaching an ultimate sanction (though possibly spurious) to our conduct. And these responses which strike so deeply into our nature seem to have the power of organizing experience; around these responses which strike so deeply (which "stand out") all else is arranged and grouped, and what does not "fit in" with these emotion-centered organizations is neglected. The very materials with which reason works are thus "corrupted" at the source.

Functional definitions, however, are not always satisfactory. It may satisfy the child to define a chair as "what you sit on" or a horse as "you ride it," but these definitions will suffice for a very limited set of circumstances. And when the psychologist has defined an emotion as "that which moves, or motivates," he has left us in a similar unsatisfactory position. In fact, there are other equally valid descriptions of this type. Emotions also disturb, disrupt, and disorganize. They interfere with our skilled performances. They also mobilize the body's energies in times of stress, enabling us to endure, and to achieve what otherwise would be beyond us. They are also the central features in the neurosis, the "nervous breakdown." And within the category of emotion we must place those deepest joys and satisfactions without which, as we say, life would have no "meaning."

It is clear that our preliminary description serves only to evaluate and interpret. We need to raise sharper questions and to study the mechanism of these reactions in closer detail.

Emotions and the Brain: the James-Lange Controversy

It is not enough to say that emotions "move" us; we need to know *how*. What is the precise order of events? What is the relation between that inner order of events which we call *emotional consciousness* and those physiological changes in respiration, circulation, and posture—in all those expressions which we call *emotional behavior?* The American psychologist, William James, and the Danish physiologist, Dr. C. Lange, raised these questions and proposed a view of the matter which completely violated commonly held views. The controversy which followed brought about the study of the physiology of emotional behavior, and may be properly called the beginning of the modern notions of emotion.

The Traditional View.—Common sense, and traditional psychology, described the order of events somewhat as follows: the outer object falling upon the sense organs sets up nerve impulses which travel to the brain; the brain changes are accompanied, in consciousness, by a perception of the object, by a feeling about the object (emotional awareness), and by an impulse toward action; lastly, these brain states lead over into the effector system, resulting in physiological changes, expressive movements, and a course of action. This picture served to do two things: it located the essential psychological problem in the region of the cerebral cortex and it viewed

the bodily states as secondary consequences of the preceding brain state.

James and Lange Reverse the Order of Events.—James and Lange proposed a view of these events which altered their time sequence, and which advanced the peripheral changes into the center of the picture. These investigators asserted that the bodily reactions were the direct result of sensory and neural changes, and that it was not until the sensory excitations set up by these peripheral changes reached the cortex—as a sort of "backwash"—and were there sensed that anything approaching an emotion occurred. Emotional consciousness was thus an awareness of preexisting bodily changes. In the words of James, " . . . we feel sorry because we cry, angry because we strike, afraid because we tremble, and not that we cry, strike, or tremble, because we are sorry, angry, or fearful, as the case may be."[1]

It is difficult, at this distance, to understand fully the bitterness of the attack upon this view. It was called crass materialism, and seemed to subordinate the psyche (traditionally located in the cranium) to physiological structures and processes of a lower order. Perhaps it was because his view would seem to make man's loftiest emotions a product of disturbances set up in the viscera (*e.g.*, his righteous anger an affair of the heart rate, breathing, adrenal glands); but in any case his view raised questions of fact, and immediately suggested empirical tests.

The Case of the Anesthetic Boy.—The case of an anesthetic boy, reported by Dr. Strumpell, was brought to James's attention. James notes:

> . . . a shoemaker's apprentice of fifteen, entirely anesthetic, inside and out, with the exception of one eye and one ear, had shown *shame* on the occasion of soiling his bed, and *grief*, when a formerly favorite dish was set before him, at the thought that he could no longer taste its flavor. Dr. Strumpell is also kind enough to inform me that he manifested surprise, fear, and anger on certain occasions.[2]

On the surface of it, this is sufficient to dismiss the theory. Here the boy is anesthetic, the bodily changes cannot be felt, and yet he is reported as *showing* shame, grief, etc. But did he *experience*

[1] James, William. *Principles of psychology*, Vol. II, p. 450 New York: Holt, 1890. Reprinted by permission of the publishers.

[2] *Ibid.*, pp. 455–456. Reprinted by permission of the publishers.

them? When James raises this latter question we see at once how difficult it is going to be to secure conclusive proof; for we are dealing with the question of a correlation between a physical change (which all can see) and an inner experience, a state of consciousness, open to but one observer. Is it not possible, James asks, that the boy's "emotional expressions may have been accompanied by a quite cold heart" and his "natural appetites and necessities (satisfied) in cold blood"? Dr. Strumpell admitted that he had not instituted the special observations demanded by the theory, and admitted that his evidence did not positively refute James.

The Experience of Actors.—A second line of evidence is considered by James, and leads to an equally ambiguous conclusion. According to the theory, we should be able to generate the emotion by assuming the characteristic attitude. To test this implication James studied the testimonials of actors, collected by a well-known critic (William Archer), in which Edwin Forrest, Charles Kean, and others reported that genuine emotional experiences occurred as they went through their roles. But not all of Archer's correspondents agreed; some were "inwardly cold" and treated their acting as skilled movements calculated to create an illusion in others. We have the right, moreover, to exercise a skepticism equal to that employed by James in the case of Strumpell's patient; for the questionnaire method does not make the "inner experiences" of the actor particularly objective, and such questionnaire statements cannot be wholly separated from the traditions of the stage, from what the public expects of the actor, or the demands of a "good press." One of two possibilities remains: either the *essential* physiological changes do not occur in some cases (in which case the James-Lange theory needs refinement) or else the bodily changes are not, as James maintained, a sufficient cause. As to how the crucial physiological components could be dissociated from the mimetic movements, in some cases, or as to their nature, James has little to say, save that they are not under voluntary control. But as to the main import of his theory James retained unshaken belief: "Refuse to express a passion and it dies." On the other hand, if we assume a cheerful countenance and "pass the genial compliment" we can feel an emotional "thaw" set in.

"Objectless Emotions."—Perhaps the best support for his view was found in the so-called "objectless emotions," wherein our organic distress creeps upon us (or arises suddenly) without any warning

antecedent perceptions, least of all an antecedent emotional consciousness. Thus the ocean voyager, so bold and confident the first day at sea, finds the nausea upon him, and the dyspeptic and heart cases experience their attacks without warning. So, too, it was with the young William James who fainted when he saw a horse bled.

> The blood was in a bucket, with a stick in it, and, if memory does not deceive him, he stirred it round and saw it drip from the stick with no feeling save that of childish curiosity. Suddenly the world grew black before his eyes, his ears began to buzz, and he knew no more. He had never heard of the sight of blood producing faintness or sickness, and he had so little repugnance to it, and so little apprehension of any other sort of danger from it . . . he could not help wondering how the mere physical presence of a pailful of crimson fluid could occasion in him such formidable bodily effects.[1]

On the whole, the arguments of James are scarcely more than persuasive. Two suggest additional possibilites. If other cases, similar to the anesthetic boy, can be discovered and with the theory in mind be given more crucial tests, some light can be thrown on the problem. And, if we could produce emotions by some method of controlling the bodily response directly, without giving our subjects any basis of, say, apprehension, and then demonstrate that an emotional consciousness ensues, we shall have proof. We shall meet with both these cases.

The most serious stumbling block in our way of finding crucial evidence is the introspective method, upon which we shall have to rely; for, as the theory is stated, we deal with the question of the time relation of two events, one objective and physiological (upon which we can place our stop watch) and the second a state of consciousness which does not lend itself readily to any timing device.

James tried to advance his case by other arguments, but none of them carried great weight. He argued that it was impossible to imagine an emotion with all consciousness of bodily symptoms absent: "a purely disembodied emotion is a nonentity." But such introspective feats convince only those who are prepared to believe. He placated those who felt that his theory was too materialistic by urging that the neural changes behind the traditional views of consciousness were no less material events; and he made a concession to these same objectors by suggesting that the aesthetic emotions (at

[1] *Ibid.*, p. 457. Reprinted by permission of the publishers.

least the classic type) were probably purely cerebral. But in his concessions he violated his own theory, and his logical-persuasive arguments lacked the support of crucial experiments.

In spite of the fact that the theory of James was a theory of emotional consciousness and rested necessarily upon introspective proof, and in spite of the fact that his arguments are sometimes of questionable value, this theory marked a distinct advance over the treatments of his time. James showed clearly wherein the endless description and classification of conscious states—without reference to the organism or to the exciting causes—was sterile and led to no new advance in the logic of behavior. To the individual who has experienced terror, the subjective accounts are valueless (and pale in comparison with his own vivid recollections). To the one who has not experienced terror, the account is in a vital sense meaningless. Therefore, if the psychology of emotions is to be of any earthly use, it must direct itself to other questions.

> Their relations to the objects which prompt them and to the reactions which they provoke are all that one can put down in a book.[1]

Even those who were to lead the attack upon the James-Lange theory owed the formulation of their problem to these investigators. So long as emotional consciousness was *mere* consciousness (or, conceived physiologically, a hypothetical brain state disconnected from the rest of the organism) there were few fruitful investigations. The moment emotions were connected with the bodily reactions, the outer "object," and the past history of the individual (*i.e.*, with items open to objective study) fruitful fields presented themselves.

The Attack upon the James-Lange Theory.—The attack upon the James-Lange theory was led by the physiologists: by Sherrington, in England, and by Cannon, in this country. Some confusion has attended the controversy throughout, as we shall see, because of a failure to discriminate between physiological and psychological questions; but the experimental work has greatly clarified our notion of the nature of emotional reactions.

Sherrington's Evidence.—Sherrington's attack may be said to follow two lines: on the one hand, he studied the behavior of animals with cerebral cortex removed or largely destroyed; on the other hand,

[1] James, William. *Psychology (Briefer Course)*, p. 373. New York: Holt, 1892.

he studied the effect of operations which destroy or greatly reduce the animal's sensitivity to those changes which James thought important.

In 1904 Sherrington and Woodworth found that cats deprived of their cerebral hemispheres and parts of the thalami still gave evidence of "pseudaffective reflexes." They noted such movements as

> diagonal cyclic movements of the limbs as in progression . . . turning of head and neck toward the point stimulated; opening of the mouth, retraction of the lips and tongue, movement of the vibrissae; snapping of the jaw; lowering of the head; opening of the eyelids, dilation of the pupils; vocalization angry in tone (snarling), sometimes plaintive; and with these a transient increase of arterial blood pressure.[1]

Now, while at first glance these facts tend to support James, in showing that impulses may discharge directly to the effectors producing the characteristic expressive movements—without cerebral involvement, Sherrington was inclined to emphasize the fact that the expressions were of brief duration and that they never amounted "to an effective action of attack or escape." Why? Did the removal of the cerebral tissue destroy the essence of the emotional response, some central and integrating process, some energizing or driving force? Or had the operation simply precluded the cortical resonance, which in James's theory would constitute the essence of the emotion? It is obvious that the experiment is not crucial for the theory, that we know nothing of the animal's consciousness, and that all we have discovered is that (*a*) damage to the central connection system produces changes in "emotional behavior," and (*b*) that without the cerebral structures (and some of the thalami) fragments of the emotional reaction persist similar to those spinal reflexes which remain after the higher centers are thrown out of commission.

In a second line of attack Sherrington transected the spinal and vagal nerves of a dog, selected for her markedly emotional temperament. The operation removed all sensations of the viscera and of all the skin and muscles lying behind the shoulder (see Fig. 54). In spite of this sensory deprivation the animal remained markedly

[1] From Sherrington, C. S. *Integrative action of the nervous system*, p. 252 New Haven: Yale Univ. Press, 1906. Reprinted by permission of the publishers.

affectionate toward her attendants, and she was easily excited by strangers; in short, there was no "obvious diminution of her emotional character." She showed joy at the approach of her attendant, anger toward a visitor, disgust toward a mixture of milk and cubes of dog flesh, delight at being fed or caressed.

How shall we interpret these facts? Even though we grant the removal of sensitivity claimed, do they show anything beyond the fact that *emotional expression* does not depend upon visceral and peripheral sensitivity? All this would fit in well with the James-Lange view. As for the animal's consciousness, we do not know

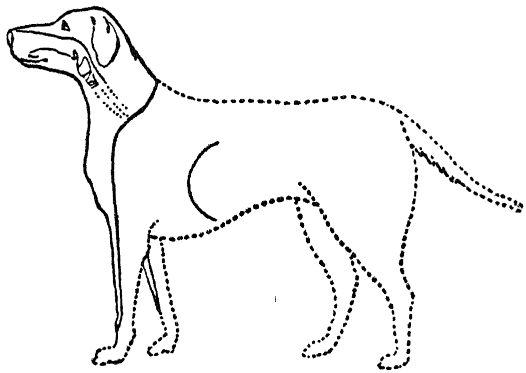

FIG. 54.—Sherrington's dog. Diagram illustrating residual sensitivity after section of spinal cord and vagosympathetic nerve. The solid line indicates the portion of skin surface still sensitive. Sensitivity of muscles and joints also corresponds to this line. The curved line indicates the diaphragm, the only muscle back of shoulder still retaining afferent nerves. The dotted lines indicating larynx and esophagus indicate the level at which sensitivity was interrupted in these parts. (*From C. S. Sherrington. Integrative action of the nervous system, p.* 260. *New Haven: Yale Univ. Press,* 1906. *By permission of the publishers.*)

how it was altered or whether, indeed, it was conscious. Nor could we do more than speculate as to the role played by the fragment of sensitivity remaining or the previous habits (and resultant memories) which had been formed.

Sherrington, on the other hand, chose to see these facts as a complete refutation of James. He felt that the animal's behavior, the consistency between facies, general course of action, and other expressive movements, clearly gave evidence of "feeling." He was willing to grant a "reinforcing" role to the sensory backwash, but felt that his experiments denied the validity of any theory which made them essential.

If we raise the question, Essential for what? we shall be able to sense the importance of Sherrington's researches. It would appear that the implication of Sherrington's work lies in the fact that he was able to show *emotional behavior* without the cerebral cortex and without the sensory backwash. Both these points are even more clearly demonstrated in the work of Cannon, which followed. Some have regarded them as persuasive evidence against the James-Lange theory; but since disproof of the latter must inevitably involve introspection, it is difficult to see how it can be obtained on any but human subjects.

The Work of Cannon and His Associates.—In America the experimental attack upon the problem proposed by James has been led by W. B. Cannon. Following the line of Sherrington—and sympathizing with his main conclusions and interpretations—Cannon proceeded with further and more radical surgical procedures. For example, the entire sympathetic division of the autonomic system was removed from the experimental animals (heart, liver, and adrenals were severed from the central nervous system), thus removing not merely the sensory consequences of the bodily reverberation, but the responses of the viscera themselves. These animals, kept in healthy state for months, gave all the outward signs of emotion—growling, hissing, retracting ears, baring teeth, striking with paw—except in those portions normally innervated by the excised neural elements.[1] We thus get the picture of emotions as basically dependent upon a neural organization—of patterns which discharge in "a fated manner" so long as neural arcs remain intact.

We may well ask just how these results bear upon the point at issue. James would have found no difficulty in fitting in this notion of a neural organization with his theory, and as in Sherrington's experiments, nothing can be shown here as to the nature of the animal's emotional consciousness following operation. Cannon makes his point, rather, in examining the changes which occur under a variety of situations and concludes that there is such a surprising uniformity in the organic reverberation—in such states as fear, rage, asphyxia, cold, fever, hypoglycemia (reduction of blood sugar)—that we cannot possibly consider these states as the "core" of the emotional responses. Subjectively fear and rage are vastly different;

[1] Cannon, W. B., Lewis, J. T., and Britton, S. W. The dispensability of the sympathetic division of the autonomic nervous sytem. *Boston Med. Surg. J.*, 1927, 197, 514–515.

the adrenal-sympathetic syndromes are surprisingly alike. These emergency states are diffuse, for two reasons: on the one hand, the neurological arrangements provide for a mass response, and, on the other hand, the hormone changes (as, *e.g.*, in the adrenals) are diffused through the blood stream, reinforcing the action of the sympathetic nervous system as a whole. Cannon and his pupils have made extensive measurements of the bodily changes throughout the emergency group of emotions (pain, fear, rage, chilliness, etc.) and they find surprising uniformity:

. . . acceleration of the heart, contraction of the arterioles, dilation of bronchioles, increase of blood sugar, inhibition of gastrointestinal peristalsis, sweating, discharge of adrenin, widening of the pupils and erection of hairs.[1]

Evidence from Pathology.—Neurological evidence of recent years, similar (in import) to the case reported by Dr. Strumpell, is even more difficult to reconcile with the James-Lange view. On the one hand, there are the cases of complete facial paralysis where the patient's hearty laugh is always hidden behind an expressionless mask and, on the other hand, the cases of pathological laughing and crying, in which the outward bursts of hilarious laughter or copious tears have not the slightest correspondence with the subjective states, nor with the outer situation. In the latter case, in fact, the expressive movements are commonly a source of irritation to the patient; the expressions do not correspond to the patient's feelings, and the responses are often set off by most inadequate stimuli (speaking to the patient, laying a hand upon the arm, etc.).[2]

A case reported by Dr. Dana[3] provides the human correlate to Sherrington's experiments. Dr. Dana writes:

[1] From Cannon, W. B. *Bodily changes in pain, hunger, fear, and rage*, p. 351. New York: Appleton-Century, 1929. Reprinted by permission of the publishers.

[2] Wilson, S. A. K. *Modern problems in neurology*, Chap. 12, pp. 260–296. Baltimore: Wood, 1929.

[3] From Dana, C. L. The anatomic seat of the emotions. *Arch. Neurol. Psychiat.*, 1921, 6, 634–639. Reprinted by permission of the American Medical Association, publishers.

Dr. J. T. MacCurdy reports a similar case: " . . . I have seen a man, whose paralysis was complete from the level of the sixth cervical down, in full possession of his normal emotional feelings. It is true that, in such a case, the vagus nerves are intact, although the entire sympathetic system is disconnected from the brain. The upper part of the alimentary canal might then be furnishing stimuli, but this would surely, according to the James-Lange hypothesis, result in a dis-

I had a patient, a very intelligent woman of forty, who fell from a horse and broke her neck at the third and fourth cervical level. She was completely quadriplegic and suffered complete loss of cutaneous and deep sensation from the neck down—with abolition of all deep reflexes. . . . She lived for nearly a year, and during that time I saw her showing emotions of grief, joy, displeasure and affection. There was no change in her personality or character. The only skeletal muscles at her command were the cranial, the upper cervical and the diaphragm. As for the vegetative system, she had the vagus, but the vagus has no active sensory fibers except the laryngeal. The parasympathetic proper was absolutely eliminated from subconsciousness and consciousness . . .

The evidence from pathology clearly does not support the James-Lange hypothesis. Patients with a fragment of the body responsive appear to enjoy unchanged emotionality, patients with facial paralysis and patients who laugh and cry "pathologically" show wide discrepancies between response and emotional consciousness.

The Experimental Induction of Visceral Changes.—Numerous investigators, attracted by the problem presented by the "objectless emotions" of James's account, have studied the effects of injection of adrenalin. Since this drug produces all the visceral changes common to fear, rage, and pain, it affords an excellent test of the theory. Marañon's subjects reported an awareness of their dry mouths, rapidly beating hearts, pulsating vasomotor changes, oppression in the chest, chilliness; but these were viewed with relative calm in most cases. Some reported, "I feel as if afraid" (or as if moved, or as if something were about to happen) or "as if I had a great fright yet am calm." Occasionally a true emotion was evoked. Later experiments by other investigators[1] have yielded similar results (four out of twenty-two subjects reporting genuine emotion). One reported:

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torted affect. It would give just that kind of predominance of one kind of visceral impression which should result in a peculiar feeling tone. Such patients have, of course, no awareness of their genital organs. But they are still susceptible to the charms of the other sex and often fall in love with their nurses. Further, it is well known that removal of the gonads in adult life may not affect sexual feeling in the slightest degree." From *The psychology of emotion*, p. 51. New York: Harcourt, 1925. Reprinted by permission of the publishers.

[1] Cantril, H., and Hunt, W. A. Emotional effects produced by the injection of adrenalin. *Amer. J. Psychol.*, 1932, 44, 300–307. Reprinted by permission of the publishers.

> I seem oppressed with a vague fear of something—feeling much the same as when I've lain awake all night frightened that Bill might die. In spite of knowing the cause of his illness the fear was not specific and neither is this. I am oppressed with a nameless fear.

Ten out of the twenty-two subjects reported states similar to emotion. For example:

> Bodily feeling of extreme nervousness. The bodily feeling almost swamps the psychic state, but the nervousness is wholly a matter of physical symptoms. I feel nervous, but I am not nervous. The reason seems lacking.

Marañon was inclined to explain the ambiguity in his findings by appealing to individual differences in the subjects. Thus, the subject who is easily frightened or who has recently experienced fear or anxiety, or the hyperthyroid case, will be more prone to give the full reaction. The other person who "keeps a firm grip on reality," who never for a moment forgets that he is in a laboratory and that this is an experimental situation, can feel the changes in the bodily state—and remain unafraid. The reaction to the total setting thus "inhibits" the development of the full response. We can imagine that fatigue or anything that would tend to relax his vigilance, or a lack of understanding of the procedure, or any slight anxiety about the outcome (or even a background of anxiety about wholly unrelated events), would tend to release the full-blown response.

Combined with the results of Archer's questionnaire one might formulate the implications for the theory, as follows: neither the assumption of an expressive posture nor the experimental induction of a visceral state, taken singly, is sufficient organic basis for an emotional response.

Neural Mechanisms and Emotional Patterns

The attempt to answer the psychophysical riddle proposed by James has not proved particularly successful. Nor has it revealed the "seat" of emotions: Archer's correspondents suggest that it is not in the postures, Marañon's results suggest that it is not in the visceral changes, Sherrington's "pseudaffective" reactions observed in the decerebrate cat suggest that it is not cerebral, and the behavior of Cannon's sympathectomized cats suggest that it is not in the peripheral changes of the autonomic system. Some of our confusion

is undoubtedly due to the double meaning of the term "emotion." Are we looking at emotional *reactions* (in striped muscles and viscera) or are we looking at emotional *consciousness* (as it is revealed in the reports of our subjects)?

In the interest of clarity let us confine ourselves for the moment to the *reactions*. Can we isolate characteristic groups of peripheral changes? Can we discover some central regulating mechanism?

Darwin's Evolutionary Conception.—Darwin, who was one of the first to consider the problem, was certain that there were such sharply defined patterns, and he was certain that they were more than a kind of "special language." In fact, emotional responses are to be viewed, according to Darwin, as inherited habits of response, originally useful in the struggle for survival. The expressions of anger, for example (red face, rapid breathing, pounding heart, clenched teeth—sometimes bared, trembling and tense muscles, quivering nostrils, bristling mane), portray the accumulated results of generations of combat. And in sadness, the tears, constriction of muscles about the eyes, the pulling down of the corners of the mouth, we see the vestiges of the infantile screaming fit. The retraction of the mouth corners he looked upon as a device to facilitate the full volume of sound; the sound served to summon aid. The contraction of orbicular muscles and watering of the eyes were likewise defensive reactions.

Thus in the struggling, fighting, avoiding, mating activities of our animal ancestry Darwin found the origin of those patterns which now, as vestigial remnants, we see as emotions. And the residues of generations of struggle now exist in the structural framework of our bodies; the purposive struggles have resulted in physiological mechanisms.[1]

"Emotional" Patterns in the Decerebrate Animal.—How deeply ingrained these mechanisms are is shown by the study of the decerebrate animal. Just as the decerebrate cat is able to right itself in falling and land upon its feet, it can be easily angered and displays an almost complete picture of animal fury. In fact, the animals are abnormally responsive, the slightest disturbing stimulus setting off the "fit" of anger: lashing tail, snapping and snarling attempts to bite, arching back, struggling movements (the cats were bound with thongs to the animal board), clawing, panting, erection of tail hairs,

[1] Darwin, Charles. *On the expression of emotions in man and animals.* New York: Appleton-Century, 1910.

dilated pupils, increased heart rate and blood pressure, increased adrenalin, sweating toe pads, increased blood sugar. Thus the patterns appear to be of the reflex order, for the operation has destroyed the creature's habits and reduced it to a state of "idiocy."[1]

Other "typical" patterns have been reported. Thus a cat with the neocortex and much of midbrain removed reacted to the noise of escaping steam by suddenly retracting and lowering its head, crouching, mewing, and then slinking off rapidly with head, belly, and tail close to the floor. Though the operation had blinded the animal and she collided with objects, she continued until she reached a corner where she crouched, mewing, with dilated pupils, and back and tail hairs erect.[2]

Bard also noted fragments of "courtship behavior"[3] in response to direct sexual stimulation, and Bekhterev had earlier noted tail wagging (dogs) and purring (cats) in similar decorticate animals, indicating—so he thought—pleasurable states. These fragmentary observations suggest that there are other patterns equally reflex in character, which further experimentation might reveal; but for the most part responses which simulate "pleasure" have not appeared in the decorticate preparations.

Localization of the Essential Neural Structures.—In a series of operations Bard was able to delimit the field which could be removed without disturbing the "sham rage." (The central mechanisms involved in the other emotions were not located.) All the structures down to the dashed line in *D*, Fig. 55, could be removed without disturbing the pattern; if the lesions disturbed areas below this point, the sham rage failed to develop. These facts, together with certain anatomical considerations, lead the experimenter to assert that " . . . sham rage depends on the caudal hypothalamus."

A Physiology of Emotions.—Let us shape these findings into a physiology of emotional responses. Fear, rage, and love reactions are of the order of reflexes, that is, automatic, mediated by subcortical structures, rather fixed in their manifestations. They differ from reflexes in that they are more widespread in their effects, involving

[1] Cannon, W. B., and Britton, S. W. Pseudaffective medulli-adrenal secretion. *Amer. J. Physiol.*, 1925, 72, 283–294.

[2] Bard, P. The neuro-humoral basis of emotional reactions. In *Handbook of experimental psychology*, p. 294. Ed. by C. Murchison. Worcester: Clark Univ. Press, 1934.

[3] *E.g.*, elevation of pelvis, treading movements of hind legs, rolling, head rubbing, and the assumption of a playful attitude.

the whole organism, striped muscles, glands, viscera. When we speak of the influence of emotions upon, say, digestion we need not try to conceive how a purely psychical state can act upon bodily processes; rather, we should think of one organic pattern replacing another. Thus, when the craniosacral branch of the autonomic system is going, as during the placid digestion of a meal—with abundant salivary and gastric secretions, peristaltic movements of stomach and intestines, the sudden invasion of sympathetic activity, as in "fright" or "anger," checks the gastric flow and inhibits the gastrointestinal contractions. We thus envisage opposed patterns of autonomic activity, mediated through the thalamus.

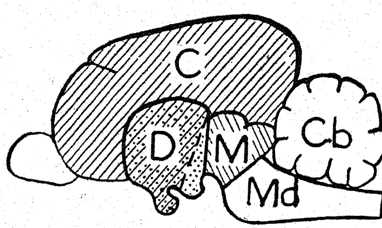

FIG. 55.—Median section of a mammalian brain. *C*, cerebral cortex; *D*, diencephalon; *M*, mesencephalon (midbrain); *Md*, medulla; *Cb*, cerebellum. Cross-hatching from right downward to the left marks the portion of the brain which can be removed without interfering with the expression of rage. (*From W. B. Cannon. The mechanism of emotional disturbance of bodily function. New Engl. J. Med.*, 1928, 198, 877–884. *By permission of the publishers.*)

Moreover, the pattern of response is wider, involving changes in posture and in such actions as running, clenching the teeth, striking, etc.

Thus, we are prepared to understand the "leaden stomach," the "nervous dyspepsia," which anxiety, worry over financial or family affairs, excitement, and anger produce. We can understand why children lose their appetite under the excitement of an anticipated journey, or why the child who has just been punished cannot be expected to evince much appetite immediately afterward.

And we can understand, too, the liberation of energy which is normally a part of the emotional picture, for the inhibition of the digestive processes is but a part of the general mobilization of the body's forces. It is as though the body, like the nation confronted with war, had to put aside the peacetime pursuits of assimilation and repair in order to divert all its energies to the emergency. The adrenal-sympathetic action speeds the heart rate, dilates the bronchioles, releases blood sugar from the glycogen stores in the liver,

quickens respiration, shifts the blood from the viscera of the trunk to the striped muscles at the periphery, increases blood pressure and the rate of flow of the blood, causes the spleen to release additional red blood corpuscles. The result is an increased supply of energy for the musculature, increased "ventilation" and removal of combustion products, neutralized fatigue, and even increased clotting rate of the blood. Even the leucocytes, those "policemen" of the blood stream, participate in the mobilization of energy (white corpuscle counts up to 28,000 being reported).[1]

These physiological facts help to make clear how in times of emotional crisis we seem to be able to tap "reservoirs of power" of which we are ordinarily unaware. Strength and endurance rise to meet emergencies. In the excitement and anxiety attending an accident or an illness in the family we are able to work without sleep for periods that would normally be impossible. Weary and flagging troops on the march are aroused by martial music, their emotional reactions giving them a "hormone fillip" that enables them to carry on. And sometimes, as in a crowd or mob, we are swept "out of ourselves" and perform actions which seem not merely beyond our ordinary capacities, but occasionally beneath our better selves. In our flushed excitement our acts seem eternally right, and we exult in the feeling of power. In the language of the subject in the adrenalin-injection experiment (see p. 262), "the bodily feeling . . . swamps the psychic state."

We can also understand why such states, when they become chronic, may result in depression, exhaustion, and general depletion of energy. The reserves of energy cannot be continuously drawn upon, else they become depleted, and the permanent exhaustion of neurasthenia—or some similar state—with its lack of initiative, its fretfulness and lack of persistence, ensues.

Of these "total states" which the physiologists have described it is possible to outline three fairly clearly marked groups. We might call one of these the "neutral" state, a condition in which bodily processes run smoothly but in which neither marked craniosacral nor sympathetic dominance exists. Here we would include all those states of placidity and calm, within which one thinks of the "well-adjusted" person as spending the bulk of his time. From this center of equilibrium, which we do not think of as in any way

[1] Jacobson, Edmund. *Progressive relaxation*, p. 19. Chicago: Univ. of Chicago Press, 1929.

emotional, the organism may be driven in either of two directions: on the one hand, into the fear-anger-pain-excitement "emergency" group with the sympathetic branch of the autonomic nervous system dominant and, on the other hand, into a pleasure group with the craniosacral division dominant.

Such a simplification of emotional life, however, does little justice to the actual richness and complexity of physiological patterns. The anger-fear group at once divides (and the work of the Cannon-Bard group suggests that there are subcortical patterns which are quite independent, here) not so much on the basis of autonomic patterns, for these seem identical, as upon the basis of the striped-muscle accompaniments. Even greater difficulty is experienced when one attempts to lump the pleasurable activities under one physiological heading. In violent exercise and in the "thrill" of the mountain climb (or roller coaster) there are both "pleasure" and marked sympathetic components. So, too, between the pleasures of eating and the pleasures of sex there is an obvious distinction; not only does the latter introduce special sacral components, but there are sympathetic elements as well.

In fact, when we depart from a few stereotyped examples and try to include all human activities, it seems scarcely possible that we shall succeed in covering the problem of the physiology of emotions with three, or four, or a dozen sharply differentiated patterns. The situations which we react to are too complex; they are not "black" or "white," but mixtures. We are impelled both to advance and to withdraw, and our visceral states show a similar confusing picture, as all who have attempted to measure these responses will testify. Only by selecting certain states of extreme intensity or by tremendously simplifying the responding structures (as by decortication) can we ever find evidence which fits the physiologist's picture of a few simple patterns controlled through the thalamus.

Cortex and Thalamus: Cannon's Answer to the James-Lange Problem.—Cannon and his coworkers believe that their physiological findings can be coupled with the observations of Dana, Maranon, and Wilson, if we consider the diencephalon as the correlation center for the patterns of *expression*, both visceral and somatic, and the cortex as the locus of the emotional *consciousness*. The sequence of events may be followed in Fig. 56: a stimulus arising at *R* (receptor) reaches the thalamus (*Th*) and is relayed to the cortex (*C*). The thalamus superimposes the "emotional" quality upon the

sensory impulse so that what would otherwise be merely apprehended, or recognized, is now felt, emotionally. At the same time, impulses descend (over pathway 2) to the visceral and skeletal musculature (*V* and *Sk M*) arousing the emotional behavior. Or, if we are dealing with the conditioned emotional responses (emotional habits) where the previous experience of the individual is causal, the impulses from the receptor may have to rise to the cortex first, and by rendering pathway 3 inactive, release the appropriate thalamic pattern. Again, the emotional consciousness would wait upon the upward reflection from the thalamus. Thus, it is not the apprehension of bodily changes, but the quality superimposed upon the entering sensory stimulus by the thalamus, cortically perceived, which gives rise to emotional consciousness.

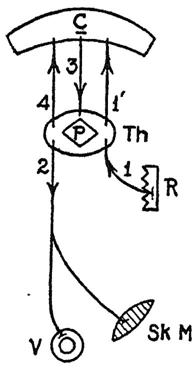

FIG. 56.—The thalamic theory of emotions. *R*, receptor; *C*, cerebral cortex; *V*, viscus; *Sk M*, skeletal muscle; *Th*, thalamus; *P*, pattern. The solid lines represent connecting neural paths with direction of impulses indicated by arrows. Path 3, from cortex to thalamus, is viewed as inhibitory in function. (*From W. B. Cannon. Again the James-Lange and the thalamic theories of emotion. Psy. Rev.*, 1931, 38, 282. *By permission of the publishers.*)

Such a conception, Cannon feels, would permit us to understand the experimental findings which we have reviewed, and also those clinical cases which present a dissociation of emotional consciousness and expressive patterns. It is also a view which can be fitted in with other studies of reflex action which indicate that the cortex functions, in general, as an inhibitor. Just as the removal of the cortical inhibition through decortication results in exaggerated spinal reflexes, agents which depress or otherwise nullify the action of the highest centers also "release" emotional behavior. Thus, the intoxicated, fatigued, or partially anesthetized patient will react to very slight provocation with anger, fear, or laughter. Normally "restrained" by the action of the cortex, the thalamic gateways are opened.

In a study of the effects of oxygen deprivation by McFarland,[1] it was noted that as the oxygen content of the air supply fell (comparable to the effect of increasing altitudes, *ca.* 24,000 ft.) unusual emotional outbursts frequently occurred. The so-called higher

[1] McFarland, R. A. The psychological effects of oxygen deprivation on human behavior. *Arch. Psychol.*, 1932, No. 145, 135 pp.

mental processes (choice reactions, discriminative responses, computation, etc.) fall off, simpler sensorimotor habits persist until the subject approaches collapse, and with the onset of anoxemia, hysterical laughter, angry attempts to demolish the apparatus—with fairly consistent reactions for a single subject, but wide individual differences—parallel a loss of the powers of critical self-consciousness. The oft-reported "exhilaration" of the "mountaintop experience" may thus be traced to a mild intoxication brought on by oxygen deprivation in the cortical cells. Such an exhilaration carries with it a definite risk for the aviator who works at the higher altitudes, for at the very moment when he most needs to utilize his oxygen supply he gravely overestimates his fitness; he feels fine, was never more skillful, could fly forever, etc.

This view serves to unite a wide variety of phenomena. Those states which impair the highest type of cortical functioning are notoriously those in which we are most subject to emotion. The onset of fatigue brings with it proneness to irritability and agitation; alcoholics lose their discriminative powers and give free reign to their "uncensored" laughter or to rage.

Physiological Measurements on Human Subjects

When one turns from the naturalist's observations of animals, or from the laboratory study of decorticate dogs and cats, to the experimental observation of human subjects under controlled conditions, the clear-cut patterns of response disappear and in their place one finds a most variable welter of changes which violate our common-sense notions of definite emotional states and tend to reaffirm the earlier notion of James, who discounted the possibility of isolating clearly defined types of response.

Consider, for example, the studies of the circulatory system. The measures of neither blood volume nor blood pressure conform to a pattern. More than twenty investigators studying blood-volume changes (by means of a plethysmographic technique) in both children and adults failed to find any consistent differentiation between pleasant and unpleasant states. The psychological term "pleasant" would seem to classify a situation, a type of organism-environment relation, rather than to indicate a definite neural pattern.

Some success is claimed by those who have used blood pressure in the "deception experiment." The subject, who tries to conceal

his guilty knowledge under cross-questioning before a jury, may reveal increases of blood pressure from 8 to 12 mm. But whereas one experimenter claims an accuracy of 96 per cent in detecting guilt, as against chance scores by the jury, other investigators have found the accuracy to be much lower (69 per cent reported by Bryan), and have found that the excitement incidental to taking other types of test (*e.g.*, intelligence tests) produces similar deviations in blood pressure.

Studies of the pulse rate reveal that the heart reacts promptly to a wide range of stimuli, but no characteristic patterns are found. Much depends upon the point in the heartbeat cycle at which the stimulus acts; and still more important is the state of readiness of the subject. An intense shock, regularly recurring, yields a pronounced effect at first, but adaptation rapidly ensues. If the rhythm is interrupted, a pronounced heart response occurs. The most that we can say on the basis of the experimental findings is that sudden stimuli produce a vaguely defined "upset"; that the form of the change depends upon the temporal factors, the intensity of the stimulus, the "readiness" of the subject.

Measures of the respiratory function have been slightly more successful. Clinicians have long noted a depression of the respiratory functions where there is a chronic depressed mood or strained expectancy. In our everyday speech we indicate the respiratory release which we experience when we "get something off our chest." Using the inspiration-expiration ratio (I/E) in the deception experiment, accuracies ranging from 80 to 100 per cent have been obtained, as against chance scores for an observing jury, the criterion for deception being a lower ratio before answering the question than after. A few investigators have failed to check these findings; and one reports that variability in results may be traced to the point at which the stimulus falls upon the respiration curve. Thus, if any sudden stimulus falls upon the inspiration phase, inspiration is continued; if it falls on the expiration phase, there is an immediate change to inspiration.

Studies of metabolic rate and of blood composition in insane patients show that the chronically depressed and stuporous patients have a low metabolic rate accompanied with hyperglycemia (excess of glucose in blood); whereas the excited, euphoric patients show a lower rate and a lower glucose content. But the milder fluctua-

tions of normal subjects in experimental settings have proved less consistent.

Gastrointestinal activity has been studied by a number of investigators, notably Cannon, Brunswick, and Landis. One might expect clear-cut results here, for the experience of the person who has suffered from some digestive disorder (*e.g.*, stomach or duodenal ulcer) clearly indicates the sensitive and speedy reaction of the digestive apparatus to outside disturbances. And the experienced clinician who has had to treat digestive difficulties has learned to look for emotional factors which might complicate his patient's problem. Cannon, Pavlov, and others have shown that salivary and gastric secretions are promptly inhibited in the frightened cat, and the X-ray study of the human subject following a barium meal shows similar inhibition, under stress, of the normal stomach contractions. At the Western Reserve Medical School, where series of observations were made upon gastric activity with freshmen serving as subjects, they came to describe a certain type of X-ray picture as a "freshman stomach," for there was apparently enough tension and excitement attendant upon the initial examinations to inhibit normal contractions, and to collect the proper series of pictures they found that a certain amount of habituation to the examination technique was necessary. But it is equally true that intense excitement of a pleasurable character will produce a similar inhibition. It would appear that all intense stimuli tend to involve the sympathetic division of the autonomic system. Thus, the facile differentiation of affective states on the basis of parasympathetic-sympathetic dominance lacks experimental confirmation. The last note is enforced, for example, by the studies of Brunswick and Landis. Using stomach and rectal balloons to record gastrointestinal activity, and employing stimuli strong enough to evoke definite emotional responses, they nevertheless found a wide variety of reactions. Apparently there are similar gastrointestinal states in such widely separated states as fear, pain, envy, irritation, unpleasantness (to use the terms employed by the subjects); and in some cases where the subjects employed the same word to designate their responses, opposite gastrointestinal effects were noted.

What all the experiments show is a disturbance, an "upset," a disorganization of normal functions, rather than a clear-cut pattern of visceral-organic expression. The results obtained show many

variations from individual to individual, and even within a single individual from reading to reading. The pattern of change depends upon the point in the organic cycle at which the stimulus impinges, and undoubtedly upon individual structural and functional differences (endocrine-autonomic balance). The effect of any given stimulus will also vary widely according to the "interpretation" placed upon it, and upon the whole habit background of the subject. Moreover, it does not appear that the words used by the subjects in reporting their experiences designate specific conditions of the organism, in so far as these can be measured; for similar words are used by subjects who show diverse physiological reactions, and a common physiological response may appear in states which the subjects describe by diverse emotional terms.

We are far from having an adequate, clear-cut, physiological picture of emotional responses. A few extreme states yield gross patterns which are recognizable; but beyond this, classification does not appear to be helpful.

The Startle Pattern.—Perhaps the nearest approach to a recognizable pattern is afforded by the "startle pattern" which has been studied by Strauss, Landis, Hunt, and others.[1] Even here there is considerable variability and the visceral changes in particular show a diffuse alteration in organic rhythms (cardiac, respiratory, etc.) rather than in a precise pattern of events.[2] In the striped muscles the experimenters report the following: shutting the eyes, a characteristic distortion of the features, raising and drawing forward of the shoulders, abduction, forward elevation and inner rotation of the upper arms, bending of the elbows, pronation of the forearm, clasping of the hands, contraction of the abdomen, forward movement of the trunk, bending of the legs at the hips and knees, and random foot movements. Any sudden, intense stimulus (electric shock, pistol shot, puff of air on the face, jab of pin, etc.) will elicit the response.[3] The entire pattern endures for less than one-half second and an ultrarapid motion-picture technique has been employed

[1] Strauss, H. Das Zusammenschrecken. *J. Psychol. Neurol., Lpz.*, 1929, 39, 111. Hunt, W. A., and Landis, C., Studies of the startle pattern: I. Introduction (*J. Psychol.*, 1936, 2, 201); II, Bodily pattern (*Ibid.*, 1936, 2, 207); III. Facial pattern (*Ibid.*, 1936, 2, 215).

[2] Hunt, W. A., and Landis, C. The overt behavior pattern in startle. *J. exp. Psy.*, 1936, 19, 309–315. Landis and Hunt report that cardiograms fail to show any uniform type of heart disturbance.

[3] Goldstein, Kurt, Landis, C., Hunt, W. A., and Clarke, F. M. Moro reflex

in the detailed analysis of the pattern. Not all subjects show the response, and of those who do show the general pattern, some do not show all the elements, and occasionally some of the movements occur in the opposite direction from the one indicated in the general description of the reaction. The experimenters report, however,

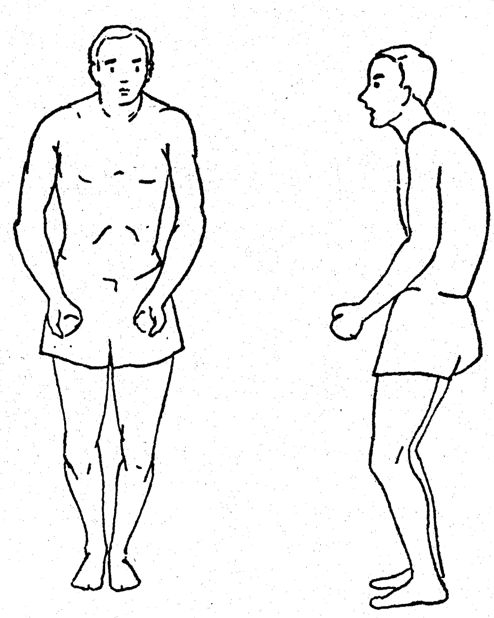

FIG. 56A.—The startle pattern. (*From W. A. Hunt and Carney Landis.* The overt behavior pattern in startle. *J. exp. Psychol.*, 1936, 19, 312. *By permission of the publishers.*)

that the total impression gained from viewing the pictures of the response in most subjects is of a fairly stable and uniform pattern.

THE GALVANIC SKIN REFLEX AND THE FREE ASSOCIATION EXPERIMENT

In the free association experiment a series of words is presented to a subject, a word at a time, and he is instructed to reply with the

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and startle pattern. *Arch. Neurol. Psychiat.*, Chicago, 1938, 40, 322–327. These investigators report that the startle pattern does not appear in complete form until the 6th week, at which time it begins to displace a somewhat similar but not identical pattern, the Moro reflex, which is characteristic of the earlier weeks of infancy.

first word that comes to his mind. This type of reaction is called "free" since no restrictions are imposed upon the subject. (In a so-called "controlled" reaction he would be required to respond with an opposite, or a verb, or to classify the word used as stimulus, etc.) Such reactions are frequently revealing, showing preoccupations, trends of thought, recent activities. Thus an experimental "crime" can frequently be detected. For example, a subject who has received two sets of sealed directions with instructions to read and carry out but one (the experimenter being absent at that time, of course) will reveal in his reactions to the word list—if the latter is properly constructed—which directions were read. The word list will contain three sets of stimulus words: an indifferent list unrelated to either set of actions, and two lists composed of words closely related to the words and actions involved in the two sets of directions. The subject will either "give away" his case by reactions showing guilty knowledge or his hesitancy will reveal his attempt to suppress just such words. If reaction times are taken, a double index may be obtained, and in most cases a careful comparison of the lists will solve the "crime."

Thus described, the free association experiment may appear to be a sort of psychological plaything, or at best another one of those "third-degree" methods to be added to the blood pressure, respiration indices of Marston, Larson, Burtt, and others. It has been treated much more seriously by many clinicians, who claim that it provides an avenue of investigating "complexes" or "the unconscious," and a tool for the exploration and description of the emotional life of a patient. These clinicians subscribe, for the most part, to the Freudian view of mental life. According to this view, we tend to repress, to shut out of mind, certain emotionally toned experiences, usually unpleasant, but though we may succeed in preventing them from occupying a place in our awareness we are not finally rid of them. On the contrary, they continue a hidden existence in "the unconscious" and plague us continually, producing slips of speech, interrupting (diverting or inhibiting) the flow of our thought, and even producing severe maladjustment and abnormal behavior. The hysterical and neurotic person is envisaged as one with too great a collection of these "complexes" in the subcellars of the mind, and the Freudian analyst endeavors, by a kind of mental catharsis, to bring these hidden emotional clusters to the surface where, in the full light of day, they can be handled rationally.

Before these "demons" can be cast out, however, they must be located, and at this point the free association experiment found use. The analyst found that, as his word list was reacted to, certain "complex indicators" appeared. The subject might delay his response or fail to respond altogether—his word reaction might be "significant" in that it clearly indicated emotion; or the subject might repeat the stimulus word, or dodge the full meaning of the stimulus and respond with a nonsense association, that is, a word which sounds like the stimulus but has no connection with its value as a language symbol (hook—book, slang—bang); or the subject might reveal emotion in accessory reactions (blush, giggle, dropping of eyes, etc.). Similarly, reactions which are too loud, too weak, too rapid, or are repetitions of previous reactions fall under suspicion. Further, on retesting, the subject's reactions should be the same, and any changes in reaction should be examined.[1]

There is also an interesting physiological reaction accompanying the words which arouse the "complex indicators." If the body of the subject is placed in circuit with a delicate galvanometer it will be found that his electrical conductivity changes somewhat abruptly with a stimulus word. In fact, each stimulus word will etch its effect on the galvanometer record, but certain ones will produce a much larger swing, (*e.g.*, such words as dead, dance, sick, pity, wicked, marry, nasty, love, worry, kiss).

Is this "galvanic skin response" (as this change in electrical resistance is commonly named) a measure of emotion? The fact that the change is commonly attributed to the action of the sweat glands, together with the fact that the autonomic fibers which accompany the peripheral motor nerves must be intact if the phenomenon is to occur, forces us to consider the reaction as a part of those autonomic changes which play such a prominent part in all emotional phenomena. But these facts should also warn us against a too narrowly "psychological" interpretation of the findings.

However useful the phenomenon may be to a clinician, like other physiological measures the galvanic skin reflex does not indicate

[1] In detecting the experimental "crime" the experimenter can frequently break through the guard of a sophisticated subject who has prepared associations in advance by repeating the stimulus word, in the manner of a cross-questioning prosecutor. The "innocent" subject usually repeats his response; the guilty one seems to feel that he must change it, and in doing so either delays his reaction or, caught off guard, he will give a word revealing guilty knowledge.

the particular type of "upset" that is involved. Abel,[1] using a careful introspective analysis of the subject's experiences, reports that under his conditions the reflex appeared most frequently when the subject reported some difficulty or block in comprehension. Other investigators have linked it with the experience of volition; but it can also be produced by deep breathing or muscular exercise. Thus, our "probe" is one which has to be used with caution; it does not "diagnose" the emotion, nor can it be taken as proof that an "unconscious complex" has been tapped. For the clinician it merely indicates a point at which to begin exploration.

The Study of Facial Expression in Adults

That there is a language of the face no one can deny. Contrast the mobile countenance, the rapid flicker of expressive movement on the face of the average person, with the inexpressive face of the blind or paralytic. But does this language of the face form a part of those massive involuntary changes in respiration and circulation that make up the visceral core of emotional behavior? Will the psychologist succeed any better here in isolating definite patterns? Occasionally the paralytic who is unable to move his facial musculature will under the stress of strong emotion show a characteristic facial expression, and the sad face of the blind will light up in the normal pattern of expression. This would seem to indicate some subcortical pattern of innervation lying beneath the paralytic's level of impairment, and as in the case of the born blind, a pattern which could scarcely have been acquired through imitation. Darwin, in his pioneer work, proceeded on such an assumption, and it has seemed to many investigators that, however much the modification imposed by social intercourse and training may alter the patterns, the essential roots of emotional expression are provided by innate biologically determined patterns.

Experimental studies again fail to fulfill the promise of the earlier observational accounts which seem to lie so much nearer to common sense. When Miss Morrison[2] studied the emotional behavior of mental defectives, for example, and attempted to classify the changes

[1] Abel, T. M. Attitudes and the galvanic skin reflex. *J. exp. Psychol.*, 1930, 13, 47–60.

[2] Morrison, B. M. A Study of the major emotions in persons of defective intelligence. *Univ. of California Publ.*, 1924, 3, 73–145. Reprinted by permission of the publisher.

in the various parts of the facial musculature, she included such items as the following:

Anger
  Expression of the face
    a. Brows contracted, eyes narrowed
    Brows raised, eyes wide and glaring
    Brows level, eyes fixed, glance cold and steady
    b. Mouth closed, lips thin, jaws set
    Mouth open (as in loud speech)
    Mouth opened slightly, lips curled or twisted
    c. Nostrils distended
    d. Face flushed, pale, or of blotchy appearance

When the brows may be contracted, raised, or level; and when the mouth may be closed, or open, or opened slightly; and when, further, the posture is described as erect and rigid, or slightly crouched; and when the voice is described as loud, or as hoarse, or as low and threatening; and when the skin may be flushed or pale, or blotchy (*i.e.*, partly flushed and partly pale), it strikes the reader that instead of showing definite patterns, the expressions studied seem to pretty nearly exhaust the logical possibilities, at least on some of the items.

Studies by Langfeld, Feleky, Ruckmick, Allport, Gates, and others have attempted to secure a measure of our accuracy in perceiving emotional patterns. For the most part such experiments have consisted in submitting to the judges a series of photographs which are supposed to represent typical emotional expressions. The subjects who posed for the photographs (in some cases a professional actor or actress) were not actually experiencing an emotion, and here perhaps we are dealing with stereotyped expressions, with a kind of gestural language, rather than with genuine emotional expressions. Undoubtedly, too, these expressions are exaggerated far beyond the normal level, for as a rule the average adult masks expression. Like the pantomime of the early silent motion pictures or the illustrations in the old elocution book of the nineties, these photographs strike one as far from typical expressions. Nevertheless, the results do not show the high accuracy one might expect. While a smiling or laughing face can almost always be "read," pain may drop to 85 per cent; fear and anger, surprise and suspicion, may be confused. Average percentages of correct judgments were found to be about 33 per cent by Langfeld, and between 21 and 72 per cent for Allport. Since different experimenters have used different

photographic materials and different numbers of emotions (with varying classifications, some not so familiar), and since different procedures have been followed, no great weight can be placed upon the numerical values in any set of results. Their negative character seems the most striking single fact. Apparently we are not so dependent upon specific facial patterns as common sense would indicate, and like the judges of infant behavior in the Shermans' experiment (see below), we need a supporting context for successful judgment in all but a few cases. If the exaggerated pattern of the actor yields such low results, it is apparent that the semimasked expression which we commonly meet will form a very poor basis of communication, indeed.

Gates was able to show that such perceptions improve with age, indicating an experience factor in reading expressions, and Allport believed that he had some evidence of improvement during a limited training which he provided. In the latter case the experimenter prepared a chart analyzing the muscle groups and indicating specific patterns which were supposed to typify the various expressions. Whether his training was adapted to his particular experimental materials (names and the specific patterns portrayed in his particular photographs) or whether it would be transferable to other materials and situations is not certain. Landis,[1] contrary to Allport, believes that "the patterns are only partially analyzable and are perceived better on an impressionistic basis than on the basis of careful study." The work of Frois-Wittmann[2] also indicates that it may be possible to find a total pattern that is distinctive when the separate elements, taken alone, may fail to prove diagnostic.

Dunlap attempted to isolate the portion of the face which was most important for the reading of expression, and for the particular photographs which he employed it appeared that the lower portion of the face was most expressive. To demonstrate this he prepared photographs of his subjects when responding to a joke, a pistol shot, an expected pistol shot which did not occur, a decayed rat, etc. The photographs were then cut so that composites could be prepared, with the parts of the face transposed. The eyes seemed to take on the expression of the lower half, and the composite photo-

[1] Landis, Carney. The expression of the emotions in *Handbook of experimental psychology*, p. 320. Ed. by C. Murchison. Worcester: Clark Univ. Press, 1934.

[2] Frois-Wittmann, J. The judgment of facial expression. *J. exp. Psychol.*, 1930, 131, 113–151.

graph was judged as the original uncut picture from which the lower part of the composite was borrowed.

Finally, an experiment of Landis'[1] indicates a great difference between those expressions which, like language, function in communication and the actual patterns which a subject may show under stress. Landis arranged laboratory situations which were calculated to produce genuine emotional reactions such as exploding a firecracker beneath one's chair, decapitating a live rat, reading sexual case histories, and other situations calculated to startle, embarrass, disgust, give pain, etc. His success may be judged by the weeping, angry language, and other signs commonly evinced by his subjects before the close of the experiment. Some twelve hundred photographs of twenty-five subjects were collected and analyzed. Instead of a typical or modal response for each situation, his subjects tended to show an individual pattern common to most of the situations. In addition to narrowed eyes and a half-smile, which were common to many of the situations and subjects, each individual portrayed certain facial patterns which accompanied varied situations and divergent (reports of) emotional consciousness. The subjects were disturbed, but the distinctive and diagnostic patterns did not emerge. If these facts are attributed to the constraint imposed by the experimental-photographic situation, the same factor may be expected to operate in social situations as well. And while common sense may insist that we do read emotional expressions—what son does not know his father's mood well enough to know whether it is the appropriate moment to strike him for an increase in his allowance?—the experimental findings would seem to indicate that the signs are likely to be individual affairs, that we should not expect to be able to identify fixed biological patterns of facial expression in social situations, and that in all probability our success (and there is reason to doubt this, frequently enough) is dependent upon a total impression involving the whole posture, and even more, the entire situation and sequence of events leading up to the moment of judgment. We read situations rather than faces, or at least when we do not have this matrix we have lost the key to the facial puzzle.

That there are traditions in the matter of expression is a matter of common observation. Some of those differences which go to make

[1] Landis, C. General behavior and facial expression. *J. comp. Psychol.*, 1924, 4, 447–509.

up national traits, sex and age differences, reveal different traditions in these matters. The voluble, expressive, gesturing, southern European, with expressive facial muscles, arms, shoulders, is to be contrasted with the sober, impassive, Indianlike Britisher, for whom enthusiastic praise is conveyed by the phrase "Not too bad." The innocent American bystander, witnessing an altercation between two French taxi drivers, may be misled into thinking that there is murder impending, whereas in their tradition it is just "gentle remonstrance." Neither does the tradition of the modern young woman conform to that which was considered fitting for the maiden of the gay nineties. Equally sharp is the contrast between the musical gushing of the city-bred girl and the more placid and sober expression of her country cousins, although the talking pictures are rapidly obscuring such differences. One wonders whether the grimness on the features of our grandfathers' daguerrotypes was really a reflection of the attitudes engendered by the rigors of pioneer life, or the facial counterpart of their consciences which they brought with them from New England, or whether taking a photograph was then a much more momentous occasion, or whether indeed it was just a photographic tradition.

All in all, our attempt to secure valid evidence for specific emotional patterns has been surprisingly unsuccessful. Neither the physiological measurements upon human adults, (blood pressure, respiration, galvanic skin reflex, etc.) nor the observation of children, nor the study of facial patterns has succeeded in discovering sharply defined responses which correlate either with the stimulating situation or with the named emotional experience. There is evidence that a variety of sudden, intense stimuli produce a widespread organic upset with changes in secretions, contractions, and postures throughout the body. These changes conform to no definite classification scheme, however, and in spite of its vagueness there is little empirical basis for a sharper definition of the state than that supplied by Woodworth, who described it as a "stirred-up state of the organism."[1]

Emotional Behavior of Infants

If there are identifiable hereditary emotional patterns in human beings, the period of infancy might be expected to reveal them in something like pure form. Here they should be in their natural,

[1] Woodworth, R. S. *Psychology*, 3d ed., p. 338. New York: Holt, 1934.

biological form, before they have been broken up, or inhibited, or overlaid by socially imposed habits. But in spite of a great deal of observation of the child, there have been all too few experimental studies, and almost no experiments of the physiological type carried on with animals and human adults. The most important stage in the history of human emotional development is thus shrouded with a haze of confusing testimony.

Watson's Classification.—Watson was one of the first to attempt to break through this confusing state of affairs, and after considerable observation of infants believed that he had found evidence for three rather definite patterns: fear, rage, and love. Fear was described as "a sudden catching of the breath, clutching randomly with the hands (the grasping reflex invariably appearing when the child is dropped), sudden closing of the eyelids, puckering of the lips, then crying."[1] He was able to elicit this response by a sudden removal of support, a sudden push, shake, or tug upon the blanket upon which it was lying, and by loud sounds. He found no evidence for fear of the dark, or of animals, or furry objects, etc., and regarded the few situations named as the only ones responsible for "instinctive" fear. The flight and hiding of older children, and fears of more complex objects and situations, he attributed to conditioning.

The second response, rage, appeared when the infant's movements were restrained. The body stiffened, arms and legs were extended and flexed in slashing or striking movements, feet and legs were drawn up and down, and the child cried with increasing intensity until its screams reddened the face and the breath was held. Holding arms, legs, or head firmly between cotton pads produced the response. The struggling movements were described as "fairly well coordinated" and as continuing "until the irritating situation is relieved." Watson noted that in older children "the slashing movements of the arms and legs are better coordinated and appear as kicking, slapping, pushing, etc."

The love response was evoked by "stroking or manipulating of some erogenous zone, tickling, shaking, gentle rocking, patting and turning upon the stomach on the attendant's knee." The response consists in cooing, gurgling, smiling, and, in older children, the extension of the arms (which Watson describes as "the forerunner

[1] From Watson, J. B. *Psychology from the standpoint of a behaviorist*, 3d ed. rev., pp. 230 ff. Chicago: Lippincott, 1929. Reprinted by permission of the publishers.

of the embrace of adults"). To the stimuli listed above Watson adds, in another account, tactual stimulation of the lips, nipples, and sex organs, and while it is clear that Watson does not desire to identify the child's response with the sexual-romantic reactions of the postadolescent years, and while he does not give at any place any clear notion of the visceral-autonomic accompaniments of the overt smiling, cooing, gurgling, laughter, etc., there is an implication that this rather vaguely defined state contains within itself the germs of what will later develop into romantic love, as well as the root of countless "approach" responses.

Do We Discriminate between Responses or Situations?—A study of infant behavior carried out by the Shermans in 1928[1] seems to indicate that Watson's list should be reduced to two. Employing four types of "unpleasant" stimulation—hunger, dropping, restraint of movement, pricking with a needle—the Shermans found that when motion pictures of the infants' reactions were shown to graduate students in psychology, nine different emotions were named for the four responses.

In the case of the response produced by hunger, for example, "13 of the 32 observers named anger, 7 named hunger, 7 fear, and so on." And in the case of the response produced by a rapid lowering of the child (Watson would call the response fear), "15 judgments of anger were given, and only 5 of fear." To be sure, the students in this case had no notion of the stimulating situation or of the number of "emotions" they were to discriminate. When, later, they were informed as to the number and type of stimulating situations, their success in naming the responses did not improve. For example, in this latter situation 49 per cent of the observers when shown the child crying because of a delay in the feeding period, called the response pain, while but 10 per cent named it correctly; 26 per cent called it anger, and 15 per cent chose fear (see Table 5). When the observers were allowed to see the stimuli there was still a great deal of discrepancy in their estimates of the nature of the emotional response, some calling the hunger response anger (as against 7 who called it hunger, 15 named anger). The response to the needle prick was named anger as frequently as it was called pain. However, it was apparent that their judgments became much more uniform when the stimulating conditions were known.

[1] Sherman, Mandel and Irene. *The process of human behavior.* Chap. 5, pp. 114 ff. New York: Norton. 1929.

Thus, whereas but 16 per cent had correctly (?) named the response to dropping under the first condition, 63 per cent chose fear when the stimulus was known. On the whole, it would seem that these responses are so undifferentiated as to be incapable of discrimination. "Correct" naming seems to arise when the observers have full knowledge of the stimulating conditions and "read into" the child's behavior the observers' own adult attitudes. This is further shown by the fact that the training of the observers seemed to have considerable effect upon their judgments, when the stimulus was unknown. Thus, medical students and nurses, serving as experimental observers, tended to look for some organic condition and

TABLE 4.—JUDGMENTS OF GRADUATE STUDENTS IN PSYCHOLOGY TO MOTION PICTURES OF THE EMOTIONAL RESPONSES OF INFANTS

Judgment	Stimuli not shown					Stimuli shown				
	Hunger	Dropping	Restraint	Needle prick	Total	Hunger	Dropping	Restraint	Needle prick	Total
Anger	13	15	16	9	53	15	5	29	13	62
Fear	7	5	5	9	26		27	4	7	38
Hunger	7	6	2	2	17	7				7
Pain	3	3	4	3	13	2	2	1	13	18
Grief	1	1		1	3					
Consternation	1	1			2					
Discomfort			2		2	6				6
Anger with fear							4	1	1	6
Anger or pain						1		1	3	5
Negative						1	1	1	1	4
Discontent						2		1		3
Doubtful							1	1	1	3
None				1	1	2				2
Irritation						1		1		2
Sleepiness			1		1					
Nausea		1			1					
Excitement							1			1
Disgust						1				1
Pain with fear							1			1
Surprise							1			1
Resistance to restraint								1		1
Anxiety						1				1
Hate									1	1
Restiveness						1				1
Repulsion									1	1
Suffocation								1		1
Total	32	32	30	25	119	40	43	42	41	166

were more likely to name colic than the students of psychology, who were looking, apparently, for specific signs of an emotion.

TABLE 5.—JUDGMENTS OF STUDENTS IN PSYCHOLOGY OF MOTION PICTURES OF THE EMOTIONAL RESPONSES OF INFANTS, WHEN TOLD THE NUMBER AND TYPE OF EMOTIONS THEY WOULD SEE

	Judgments per cent					
Stimulus	Hunger	Pain	Anger	Fear	Don't know	Total
"Hunger".	10	49	26	15		100
Needle prick	18	20	20	33	9	100
Restraint	18	23	31	18	10	100
Dropping.	21	19	27	30	3	100

Further experiments when the child itself was substituted for the pictures yielded no better results. Apparently the mother who believes that she can discriminate between the different cries of her child is either deceiving herself by reading into the child her own attitudes or else is able to make a good guess as to the disturbing condition, thanks to her knowledge of the child's routine.

From all their observations the Shermans conclude that when we classify the emotional responses of infants we are really classifying stimulating situations. When, as in estimating the internal responses of an adult who has learned to mask his overt manifestation, we are forced to turn to the stimulus and estimate—on this basis—what his most probable intentions and expectations are we are following a similar course. If the unpleasant situation invokes attack, or preparations to attack, we call it anger. If it invokes avoidance, flight, or defensive reactions, we call it fear. But, apparently, within the group of stimuli employed by the Shermans differential patterns have not yet appeared. This is not to deny the obvious difference between the smiling, cooing, gurgling child and the crying, struggling one; but it does imply that beyond these two diffuse patterns further differentiating characteristics must wait until the child builds up definite ways of dealing with the outer situation.

The Shermans are further of the opinion that emotional or tempermental differences between children are largely due to stimulating conditions and to the method of handling. They comment upon the difference between the children on the private

wards (with private nurses, subject to more frequent handling, visitors, etc.) and those who are not disturbed except when absolutely necessary. The former are likely to be irritable, to cry long before feeding periods, to be restless, and to demand a great deal of attention. The latter tend to be calm, placid, and to remain quiet for long periods. The handling, the Shermans argue, tends to lower thresholds and increase irritability in the physiological sense, in addition to conditioning the child to make specific demands. Further, as the child grows older, the development of tantrums will depend upon the type of conflicting situations pressing upon the child, and upon the degree of success achieved by his emotional outbursts.

The Development of Emotional Behavior

Variability in Emotional Behavior.—As the individual passes from infancy through childhood, adolescence, maturity, and old age, his emotional life undergoes a maturation and development. Originally invoked by a comparatively few situations, the emotional responses gradually become attached to an everwidening group of stimuli and the patterns of expression change from the gross, squirming, chaotic, random, and unformed mass activity to the coordinated flight or attack, the coy and courtly behavior of romantic youth, or to the extended flights of imaginative thought of the creative artist. The changes in the stimulus pattern and the alterations in the patterns of expression leave little that is constant through this period of change save possibly the core of visceral upset. It is even questionable whether the autonomic patterns, if indeed there are very definite patterns, escape the process of conditioning. As we shall see later, the salivary glands are subject to conditioning, and there is no reason to believe that the other glands, endocrines included, and the smooth muscles of the alimentary canal, the heart and blood vessels, should escape. In fact, the failure of physiological measurements to yield consistent and uniform patterns suggests that a process of decomposition and reorganization has altered the visceral pattern itself. Because all of us use the same word, fear, to describe our attitude in a certain situation, it does not follow that we experience it in the same way or show the same patterns of muscular contraction. As a matter of fact, one of us will have a lump in the throat (constriction of the esophagus), another a spastic intestine, another will sense the con-

striction in the large muscles of the abdominal wall, another will grow pale and break into a cold sweat. It is probable that some of these differences in patterns are affairs of organic make-up, a difference in the development and reactivity of the bodily structures. (The possession of hyperactive thyroids and adrenals, for example, will certainly alter the picture.) In part, too, the differences may be attributed to the physiological condition of the moment.

The Role of "Conditioning" in Emotional Development.—That the visceral elements as a whole are subject to conditioning is shown by countless examples, both clinical and experimental. Hamilton's case, described later (see page 295), shows how one childhood episode at the age of eight continued to color a definite type of situation with a panic of fear well into middle life. Watson was able to show that the fear reaction produced in his infant subjects by the loud sound of a steel hammer striking an iron bar could be made to appear in response to a rabbit which had previously aroused no such response, simply by presenting the animal at the moment the sound was produced. Precisely as in Pavlov's experiment the fear became conditioned to the innocuous stimulus, and the character of the associated object was not important so long as the reinforcement with the loud sound continued. Other objects, not so presented, but possessing certain characteristics in common with the conditioned stimulus (*e.g.*, furriness) spontaneously took on the fear pattern. Our everyday experience is too full of similar instances to belabor the point. An automobile accident, a thunderstorm, a too-spirited dog or horse, a death in the family, etc., will leave their effects for days, and even years. Thus the present situation is crowded with the "images" of past events, and the stimuli are able to energize our reaction systems, mobilizing and releasing the deeper levels because our past conditioning has equipped us with expectancies of more than is presented to the senses. Nor need we be fully aware of that which our organism anticipates. Long before language reactions are developed, or before there is any reason to posit anything like the patterned consciousness of later childhood, such conditioning will operate upon the infant. And the labors of the psychoanalyst who endeavors to unearth the causes for his patient's emotionality, causes which are completely hidden from the ordinary waking consciousness, show that the adult's preparations to respond are much broader than his power to formulate them. Like the person whose good taste springs from having saturated himself

in the best that has been thought and said, and whose judgment may be immediate and sure and yet incapable of formulation, our emotional subject may show a very definite emotional response to a situation without being able to call up the past events responsible for its establishment. The lines,

> I do not like you, Doctor Fell,
> The reason why I cannot tell;
> But this I know, and know full well,
> I do not like you, Doctor Fell,

express well enough the type of problem the psychoanalyst is confronted with. Our emotional past has endowed us with more "psychic scars" than we can always arrange and classify at the moment of crisis. In fact, there is no reason to believe that the psychological difficulty of the moment springs from any simple set of situations. A complication of tendencies, with mutual interference and support, may be drawn from different situations located at widely separated periods of our lives, the many-sided character of the present moment producing a psychological mélange, a grand mixture, instead of a neatly sorted and ordered selection from some specific portion of the past.

Disruptive and Sthenic Emotions.—Thus it is that our emotions may be disrupting, disorganizing, and crippling, as well as energizing and motivating, forces. The past which is invoked may be quite out of harmony with our present purposes and the reactions produced untimely and maladaptive. It is not merely that we are dealing with biological patterns suitable to the jungle, and hence unfit for modern life (how far we have come from the jungle seems at times to be an open question); but rather that there is an inconsistency within our own life span. Our past may have trained us to meet some terrific onslaught of stimuli in connection with some particular cue. The presence of that cue in another situation which calls for calm deliberation and the exercise of coordinated skills will, of course, be disrupting. Since the psychopathologist deals with just such cases, namely, those who find their emotional responses untimely, disrupting, and disorganizing forces, there is a general tendency to devaluate emotional behavior. But it should be remembered that there are positively toned emotions as well, and a timely mobilization of energy as well as the untimely. The past

may endow us with "psychic scars," it is true; but if its burdens have not been beyond our strength it will have endowed us with a weather-beaten courage and the confidence that tested strength can bring.

These observations should prepare us to understand the question raised at the beginning of our discussion of emotions. The source of the power of emotion-invoking symbols and their ability to arouse us to action, to motivate us, must lie in those stimulating situations which originally produced them. In tapping the appropriate portions of our past these symbols release our energies. The organism's power to retain past conditioning makes these energy-releasing events of the past continually available.

Changes in the Response Pattern.—There is a second type of modification to be noted. Not only do our emotional responses become attached to an ever-widening group of stimuli, but the pattern of expression changes radically. The originally chaotic, massive, and disorganized squirming of the child becomes an equipment of adaptive skills. The restraint of movement which produces a blind, slashing struggle in the infant may become a more skilled revolt against parental authority in the older child, a planned campaign of revolutionary activity in the class-conscious worker, a letter to the newspaper editor on the part of the outraged citizen, or campaign of slander on the part of the defeated candidate. As the original patterns find release, adjustments which work, "mere" emotions are replaced by skills, and in proportion as the latter are successful in removing the causes of the disturbance the periods of pronounced "upset" should grow shorter. In fact, as experience teaches us when to expect them—in advance—(just as we provide coal against a severe winter-to-come), many will not arise at all. In this sense we may look upon undue emotionality as, in part at least, a symptom of a failure to acquire the proper modes of reaction, as a failure in our training and habit equipment. The emotional response is thus a symptom or *result* of past failures, and at the same time it provides the energizing and motivating *cause* of the further trials which are necessary if a more satisfactory adjustment is to be achieved.

Social Factors as Regulators of Expression.—Adult society also insists upon a certain amount of suppression of emotional expression. To be sure, there are many codified forms which are acceptable, and custom provides both the situation and the pattern for a variety of

"moral holidays" wherein we may find release from the inhibitions of adulthood. The ecstatic jumping and shouting of Holy Rollers, the antics of the crowd at the football stadium, the righteous indignation of the revivalist, the hilarity of the beach party, all pass at the appropriate time and in the proper group without calling forth the epithet "Infantile!" But, in general, the social group demands from all, save possibly those precious few who can properly claim excuse because of "genius" or "artistic temperament," a relatively subdued pattern of expression, and the childlike, uncontrolled outbursts appear either ridiculous or a serious regression, according to their gravity.

In place of the screaming of the child we are expected to substitute a verbal protest, or at a further level of inhibition only our thoughts are permitted to race on; overtly we must betray no sign. The inhibition of external expression does not put an end to the matter, however. For example, when we have failed to make a very brilliant showing at the extemporaneous after-dinner speech, we find ourselves returning again and again to the business of speech-making, and long after we should have fallen asleep we are busy constructing telling phrases, apt illustrations, and entertaining stories. And our failure to achieve successful dominance in some conflict situation will leave us tense, mentally racing through scene after scene in which we thoroughly trounce our opponent in imagination, or achieve at least some more satisfactory resolution of our tensions. All of which suggests that the stream of energy released by the emotion-producing situation will flow into whatever channels are available. All our habits, and particularly those which the immediate situation calls for, will participate in the stream of energy. Consequently, as our equipment of skills increases and changes, our patterns of expression undergo change. There is nothing fixed or eternal in the connection between the visceral "upset" and the striped-muscle accompaniments. Adrenal activity will supply freshly oxygenated blood and a richer food supply; but the pattern of striped-muscle contractions which consume this energy will depend upon the habit equipment and upon the outer situation, which serves first to arouse it and then to shape, regulate, and delimit the external expression.

Biological Factors in Emotional Development.—The biological process of growth and maturation will also provide a succession of changes in emotional patterns, although its effect will be so inti-

mately woven into the texture of changing habits that it will be difficult to view it as an isolated cause. The recent studies of the endocrine glands have shown how body chemistry affects emotional reactions. The thyroids, adrenals, pituitary, and the gonads will alter these bodily reverberations as their level of activity changes. The sharp changes at adolescence, menopause, and pregnancy have long been known to entail marked psychological, and particularly emotional, effects. It is true that much of the *Sturm und Drang* of the teens is a product of the new opportunities and demands which the adolescent faces, but the increase in the range and vigor of the responses of the reproductive glands certainly intensifies the stresses of the period. And conversely, the serenity which some succeed in achieving in old age is associated with the diminution in the supply of the chemical catalyzers which speed metabolic processes and light the "fires of spring." On the other hand, old age brings on a physiological impairment which produces a new list of baffling situations, and tasks which were previously performed without effort now become minor crises and sources of emotion. Being sheltered, and put on the shelf, and crowded out in the competitive struggle by younger and more vigorous contestants, all call for drastic readjustment, and the speed of change demanded may outrun the individual's capacity and, as in adolescence, the actions called for by both organism and society may exceed the equipment of the individual. Such a view again reminds us that a simple, mechanistic, stimulus-response view of the emotional patterns will not do. When the very physiological groundwork is constantly changing we cannot expect to find a full account of emotionality at any period in an account of the previous history of the individual.

It is further probable that our attempt to get a conception of the universal aspect of emotional behavior has overlooked the important factor of temperament, of individual differences. There is no reason why we should not expect as wide a range in original endowment in this field as in the field of intellectual attainment where intelligence tests have achieved at least a rough measure of the range from genius to feeble-mindedness. No clinician can remain indifferent to the fact of constitutional differences, and there is no reason why the psychologist should neglect these factors in treating emotion. But it is probable that here, as with intelligence, we are more likely to find differences in levels rather than in qualitatively distinct

types. A vigorous adrenal-sympathetic pattern may be a factor in the production of a whimpering, frightened, timid child; or it may help to make an aggressive, easily angered, tantrum child. Cannon's results more than suggest this. The ease with which energy released by the visceral upset flows into whatever channel is available makes one think that the type of temperament displayed by the child, his dominant emotional pattern, will depend upon the way he is handled. If the environment yields in response to the screaming fit, and the tantrum "works," then it will be fixated. If, on the other hand, he is subject to an extremely strict discipline, all expressions will be driven underground, his spirit will be broken, and he will be driven to indirect expressions, to tears and crying, to imaginative "attacks," or to whatever cajoling devices he may discover workable. The variability of the patterns revealed by conditioning experiments, and the experience of those who deal with children, would seem to point in this direction. This is not equivalent to saying that one child will present as simple a discipline problem as the next or that the vigor of emotional reactions is at all equated; but it does assert that with skill and care the pattern or type of expression can be directed.

The Situation as an Integrating Factor.—Finally, there is an approach to the problem of emotional development which might be called *situational*, or functional. One is impressed by the fact that it is often not so much the physical character of the stimulus, but rather its function in the total behavioral situation, that makes it a cue for emotional responses. Frequently it requires a very slight alteration in the objective stimulus to produce a complete reversal of the pattern of response. The physical stimulus of the playful pat may be of much greater intensity than that received as a warning, but the former invokes laughter, the latter tears. In bathing and dressing the child an ever so slight change will transfer what is often a game into a very unpleasant affair. It is when the mother is a little vexed or a little in a hurry, or when the procedures interrupt other activities of the child, that her assistance becomes restraint of movement and cooperation becomes conflict. Similarly, the words of one adult will seem to us to be useful suggestions while the same words on the lips of another will be unwarranted interference, meddlesomness. All this suggests that the matrix within which the stimulus falls, the meaning of the total situation, and the relations between the parts are more important than the isolated

physical stimulus. This, again, sets a strict limit to a purely mechanistic, neurological, stimulus-response analysis.

Consider Kempf's description of one of his patients:

> A young woman's personality was almost annihilated by a prolonged turmoil of emotions. She *admired* her husband's ability but suffered *anxiety* from his extravagant waste of money. She *loved* her baby but felt herself unfit to be its mother because of her *shame* from masturbation. She was in a perpetual state of *fear* lest she would be without means and her wrongs discovered. She was *angered* because of the frank aversions of her relatives for her husband, and suffered from feelings of inferiority (*fear*) of long standing, and mingled with all this was a distressing compulsive *eroticism*. Finally, bewildered, she attempted suicide.[1]

Taken alone, any one of these problems presented by the patient could be handled, or at any rate lived with and tolerated. It is the "sea of trouble," the combination of events, the stress of conflicting impulses generated by the particular environmental constellation that finally proves too much. How inadequately we shall handle such individuals when we seek the explanation of the suicidal tendency in some inner, possibly hereditary, tendency. Viewed from the safe vantage point of our more tolerable adjustment it is easy to invent some personal weakness to explain the "abnormal" conduct. So the comfortably ensconced bourgeois looks upon the improvidence, the lack of cleanliness, the bickering, the suspicion and distrust which he may discover when as social case worker he visits a certain proletarian home. So, too, our newspaper editors occasionally try to explain the turn of international events in terms of supposed national traits, the character of the German people, the aggressiveness of the Japanese, "psychologizing" a complicated political and economic complex of events and substituting mythical mental factors for a sound objective analysis of events.

Thus, we see that the emotional career of an individual will depend upon the sequence and complication of situations which life presents to him, and once we have grasped the broad outlines of the physiological and psychological problem presented by emotions our problem is one of ecology or sociology. The reconstruction of the person who has suffered an emotional breakdown will therefore depend upon the creation of a workable plan of life and the

[1] From Kempf, E. J. *Autonomic functions and the personality*, p. 69. Washington: Nervous and Mental Disease Publishing Co., 1918. Reprinted by permission of the publishers.

discovery of an environment which does not drive one tendency against its fellows. The "demon" lies not merely within. The outer world must be re-created. When one reads of an increase in suicides or an increase in insanity one does not need to posit some progressive degeneration of the human germ plasm and search for causes in the genes. It is possible that the pattern of life afforded by our civilization is at fault.

The Control of Emotions

The Purpose of Control.—It should be made clear at the start that the study of methods of emotional control does not aim at the complete suppression of emotional life. Some sort of affective toning will accompany all human behavior; and even if it were possible to keep this tone at some monotonous intermediate pitch, few would desire such a state. Nor could it be psychologically recommended, save in those extreme cases where the slightest excitement is disastrous, and the individual must guard against the slightest excess in his expenditures of energy.[1] Who would not accept the risk of pain and emotional distress rather than forgo all hope of pleasure? Such an extreme fear of consequences, amounting almost to a fear of life, would itself be counted pathological.

All of us have experienced the destructive effects of some emotional experiences, however, and if we have thought about them at all we have sought some method of controlling these wild horses which exhaust, mortify, pain, and at times almost destroy us. Dr. Edward Weiss[2] estimates that about 35 per cent of the patients who consult the general practitioner of medicine are suffering from disorders that are entirely dependent upon emotional maladjustment, and that in the balance of the cases at least half of them have symptoms which are aggravated by emotional factors. Frequently, when the practitioner can find no organic basis for the complaints, he dismisses the patient as a neurotic or contemptuously refers to him as a malingerer. And the failure of the physician to understand the psychological origins of these difficulties is in a large measure responsible for a lucrative type of quackery.

[1] Janet, Pierre. *Psychological healing*, Vol. 1, p. 697. New York. Macmillan, 1925.

[2] Weiss, Edward. The study of the emotional life in the practice of medicine. *Med. Record*, 1935, 141, 68.

Then there is the type of case met by the specialist in nervous and mental diseases. Two instances may serve to illustrate.[1]

Case 1. *Conditioned Fear Reaction*

Symptoms:

Whenever this patient left her house by the front door and went out into the street she felt as if some dreadful thing were about to happen. If she ventured too far from her house a fear of imminent death was apt to overtake her. She would feel herself "going down, down, down," would break into a cold sweat and, if unsupported, would sink to the ground in a paralysis of fear. She could walk out of the back door and into her back yard without precipitating such attacks. At times, while indoors, she would have milder anxiety attacks with fear of death, cold sweats and weakness of the lower extremities. Her current symptoms were gastric distress with nausea, constipation, paresthesia of the scalp, tired ache across the hips and in the lumbar region, vague discomfort over the heart, and cold extremities. There was a purely subjective lateropulsion (she felt that she was falling to the left, but actually walked normally indoors) whenever she was tired or excited. At times when she tried to talk she could only weep.

Discussion:

Three years before consulting Dr. Hamilton the patient had been in an automobile collision, and her symptoms dated from that time. Although no one was seriously injured, the patient at the time of the collision expected to see her daughter and grandchildren killed, and reported that she shut her eyes "to shut it out of her mind." Her memory of the event was very confused, like a poorly recalled nightmare, and Dr. Hamilton suggests the possibility that her attempt to inhibit "full psychical reaction" had somehow left her in "a state of preparedness to complete the originally initiated psychical reaction." The street stimuli, although insignificant parts of the original setting, now serve to set off the total reaction. Even the pounding of her own heart would sometimes precipitate a full-fledged anxiety attack while she was reading in her own home.

[1] From Hamilton, G. V. *Objective psychopathology*. St. Louis: Mosby, 1925. Case No. 1 is reported as Case 88, page 122. Case No. 2 is reported as Case 90, page 125. Reprinted by permission of the publishers.

Case 2. Conditioned Fear Reaction

Symptoms:

At twenty-four, while sitting in one of the front pews of a church, he happened to glance over his shoulder and observe that the aisle was blocked by ushers and incoming members. He suddenly felt dizzy and ill, and fell into a terrible panic. He felt that if he could not at once escape from the church he would go mad with fear, and rave like a madman. After that, whenever he found himself in any situation where quick, unimpeded exit from an enclosure was not apparent, he would have one of these attacks. He could enter a moving-picture theater while the lights were dimmed and leave it before they were turned up, but if he miscalculated the movements of the crowd, and saw the aisles blocked by incoming and outgoing people he would have an attack. Taking communion at church was a great hardship because it involved the blocking of all easy exits from the place where this rite is performed. Matters were brought to a climax when he was called upon to preside at a labor convention, where his duties required him to face an audience which seemed to block his exit. He was compelled to seek an excuse for leaving the auditorium, fearing complete loss of self-control.

Discussion:

The patient could give no explanation for his panics. There was nothing that could be found in his surroundings, his family life, etc., that seemed to account for it. Instructed in the method of free association, the patient discovered some days later, at his own home, that there were experiences which had occurred when he was eight years of age (he was in his fifth decade when he saw the physician) which seemed to be related to his present difficulties. He had been left, by his farmer uncle whom he was visiting, with the hired man. The latter, returning with a freshly captured live raccoon, was amused to see the little chap's fear of the animal. The boy ran, terrified, when he attempted to show him the animal, and the farm hand pursued the boy into the house; and when the boy had attempted to hide in an upstairs bedroom he threw the animal into the room after him, and locked the room. The boy tried to escape, but could not, and it was not until his shrieks of terror had finally frightened the farm hand that he was released. Even the recall of the episode more than thirty years later produced a lively emotion of fear. His panics, on the other hand, which had appeared at intervals since his twenty-fourth year, had never been regarded as

in any way related to this event, nor had they even reminded him of it—to judge by his inability to give the physician the slightest clue as to the cause of his difficulties (*i.e.*, in the first place).

The foregoing observations and illustrations make it obvious why the individual should want some means of controlling his emotional reactions—reactions which send one scurrying to the physician with gastric complaints, tachycardia, panics of anxiety, chronic fatigue, etc.; reactions which thwart the pursuit of professional career, or which confine one to an extremely limited and highly protected round of routine activities, beyond the pale of which lies complete collapse[1] . . . obviously are in need of control. What can an objective psychology suggest?

Proposed Methods. 1. *Changing the Environment.*—In a stimulus-response psychology, what is more natural than to suggest a change in the environment? Our emotions, like all other categories of response, are reactions to stimuli. It is but natural, therefore, that we should propose either (*a*) removal of the disturbing stimulus or (*b*) the acquisition of equilibrating conditions. When we describe emotions as "motivating" factors we are simply commentating upon the fact that these tensional states, conditions of disequilibrium, drive us mercilessly until we have found the conditions which release the tension and restore equilibrium. Control of emotions is most simply phrased here as control over the environment.

In some respects an emotion is like hunger. The tensional state which arises in the absence of food, the characteristic autonomic and visceral condition, the contractions of smooth muscles, and the stream of proprioceptive and interoceptive stimuli, can all be duplicated in the physiological mechanisms which we call emotion. The "imagery" of appetizing dishes, the anticipatory responses, all have their analogues in the angry person's imaginative trouncing of his opponent, in postural tensions, etc. Now, the problem of the control of hunger is simple. One does not urge the subject to use his will power, to repress these organic urges, to "rise above" the flesh. We control hunger with food. And common sense urges that we treat our depressions and anxieties in a similar manner. To the person who is blue and bored, one frequently gives the advice: wash, dress up, step out for dinner, go to the theater, hear gay music, meet your friends, buy a new garment, or a picture, or a book, etc. In

[1] Leonard, William Ellery. *The locomotive god.* New York: Appleton-Century, 1927

short, displace the undesirable reaction by putting yourself in the way of the sort of stimulus that will *force* it out. Instead of attempting to lift one's self by the bootstraps, or instead of trying to manipulate one's "mental state" directly, one can depend upon the efficacy of the stimulus.

Now, this is an extremely common device. From the psychiatrist who recommends the travel cure to the plain citizen who seeks an "escape" in the detective story, the romantic novel, the theater, the automobile, alcohol, gambling . . . the process is similar. All of us have our favorite "balancing factors" through which we work out a tolerable existence without making any fundamental readjustments in our life plans when we get into emotional difficulties.[1] And so we say to the mother of the child who is timid, fretful, anxious, fearful, "See that the child is not overstimulated. Keep the dogs away. See that he has a quiet place to sleep in," etc., etc. Or we recommend a rest, some diversion, or our favorite balancing factor to the adult who seems "on edge."

Now, there are certain limitations to this method, for all its universality and the sanction of common sense. In the first place, it is best thought of as a temporary measure suitable for minor disturbances. Most of us have work to do and cannot seek an endless succession of these intellectual and social "cups of coffee." Nor is it apparent that those who are free to pursue such fillips are the best balanced emotionally. Even a serious maladjustment can be tolerated, covered up, and lived with—for a while. But in the latter case it is much more important that something be done about the *main problem* before energy is frittered away in an endless sampling of escape devices. The main problem will have to be faced, and it is better to do so before one is psychologically bankrupt. It is apparent, therefore, that the mere knowledge of balancing factors, the mere introduction of minor changes in the environment, while they may bring temporary relief, may be therapeutically unsound in the long run.

In the second place, this type of therapy involves considerable freedom of movement and control over the environment. It is

[1] Travel, the thrill of dangerous sport, creative hobbies, collecting, romantic adventures, music, social occasions, various "creature comforts," some form of "display," various forms of "communing" with nature (hiking, camping, fishing, etc., for the nature lover), intellectual companionship (and argument), community and cooperative enterprises.

not always easy to take the vacation trip or the "sea voyage" that is recommended. Some situations hold us and have to be faced. The changes which must be accomplished if we are to achieve equilibrium may be fully known to us and yet impossible to bring about. Are we, then, without a measure of control? It may be, for example, that our own crushing perplexities are the product of a social system which we as individuals cannot change. Perhaps with the utmost cooperation on the part of our fellows it will seem that changes can come with the snaillike pace of geologic events. What of the problem of control in the meantime?

There is, in short, a distinct limit to which this technique can be applied. The parent who attempts to control the child's environment discovers soon enough that there are limits to his powers. Moreover, creating an excessively simplified environment does not prepare the child for the inevitable transition into the world. And the solicitous parent who embarks on the task of substituting stimuli may find that, for example, the child who is afraid to go to bed alone in the dark will demand first a light, then an open door, then someone in the room. The fear and anxiety seem insatiable and progressive demands have not restored equilibrium.

Finally, for all the more obscure and serious types of emotional maladjustment, the method demands a clear-cut knowledge of the causes. The young man who, in a fit of depression, decides to run away and try another job, to make a fresh start, may find that in taking himself along he has laid the foundation for his next failure. If the causes are only partially external to the individual, if the environment is merely the exciting cause, then more radical modes of treatment must be involved.

2. *Expression as a Method of Cure.*—On the face of it, *expressing* the emotion seems to be anything but a method of control, but it is often urged, not only by the layman, but by psychologically trained counselors. It is urged, for example, "Go on. Have a good cry. Get it over. You'll feel better. Get it out of your system." Or one hears, "The trouble with you is that you keep it all to yourself. You ought to have it out with him."

And even the psychiatrist sometimes indulges in descriptions of personality differences to a similar effect. That is, he points out that the severity of an emotional crisis is likely to be much greater in the case of the inhibited, or self-contained, individual who shows little or nothing on the surface, repressing all expression. The

mercuric, expressive individual, on the other hand, who seems at the moment of the crisis to be plunged into the very depths, emerges smiling shortly thereafter, as though an emotion were like a charge of energy which needed to be expended, and as though the violent expression had purged his system, had drained off his pent-up charge. Whereas the tight-lipped, repressed, self-contained Nordic is pictured as bearing his sorrows and his grudges in silence, permitting them to endure too long and exhaust the reserves of energy, the volatile Alpine or Mediterranean type (typically the southern European) is pictured as one who will explode, weep, curse, wail, and have it all over with. We often observe that it is the suffering martyr who is so hard to get along with; and if this analysis is correct, he wrongs himself by his firm grip on all expression.

A Popular Interpretation.—In spite of the fact that it is very difficult to catch a reputable psychologist in print supporting such a doctrine, the notion that psychologists (and psychoanalysts) support this generalization has widespread currency. It is probably traceable to the description of clinical cases of those individuals whose whole emotional life seems driven underground (figuratively speaking), who have led a thwarted, inhibited, repressed sort of existence until that which was repressed broke out in some abnormal, and possibly violent, form.

As long ago as Hippocrates there were those who urged that hysteria occurs in those women who suffer from an insufficiency of sexual relationships; and in our own time the Freudians have expressed something not altogether foreign to Hippocrates's idea. The Freudians have urged that repression of the sex instinct (very broadly defined, to be sure) generates the anxieties and depressions with which the psychiatrist has to deal. The whole doctrine is sometimes figuratively phrased in terms of drainage. Repression is thought of, apparently, as like the weighting of a safety valve; and expression (the remedy) as a draining off of the accumulated head of energy.

A Reconsideration of the Method of Expression.—Against this loosely conceived and highly figurative gospel the more cautious analyst will urge that: (1) An emotion is not a head of steam. It is a response to stimulation. So long as the stimulating conditions remain unaltered the emotion will remain essentially unaltered (save, of course, as fatigue or other physiological changes of a similar order supervene). There is no reason, from what we know of

response mechanisms, to infer that an emotion, the expression of which is inhibited, is any more severe than the reverse. That is, if the term "expression" is made to cover any and all motor accompaniments which communicate the presence of an emotion. Neither is it to be inferred, from anything we know of human physiology, that striped-muscle movements (involved in expression) will dissipate the energy of the emotion—unless they alter the stimulating conditions.

(2) With respect to the Freudian aspect of the case, it is undoubtedly true that one can find cases where sexual "starvation" lies at the root of emotional instability, and particularly of a hypersensitivity to stimuli in this field. These cases will appear to lend justification to the expression method of treating emotional problems. But it is also true that the sexual appetite is one, like many others, which grows with expression—up to a certain point of satiety, and that expression may therefore increase the difficulties of control. Moreover, in treating of an adjustment which is so tied up with our social fabric, so hedged with taboos, and so fraught with social consequences, the simple formula suggested by our generalization offers an inadequate simplification of the problem. It is equally true that the psychiatrist's notebook will not offer support to the popular simplification of the Freudian view. Many of those who need psychiatric counsel suffer, it would seem, from unwise or excessive expression, not from repression.[1]

(3) Conceived in the broadest sense, emotions are the great motivating forces in life. They represent conditions of tension, of disequilibrium, of disturbance; and we do spend our lives in *expressing* them, in finding satisfactory releases for the tensions, in altering the conditions which have disturbed us. An *effective* expression is what is needed. Such an expression *liquidates* the unstable situation. A good cry may evoke comforting stimuli from the environment or accomplish what a direct attack upon difficulties will not. The expression of irritation may lead to a new and better understanding between friends. None of these things may follow. Our expressions may be futile, fumbling attempts, which get us into further difficulty. Or they may be *mere* expression, mere signs of agitation or depression, which do nothing to alter the situation which lies at the basis of our state. There are times, it is true, when expression of any sort seems better than the agitated or depressed

[1] Janet, *op. cit.*, Vol. I, pp. 589 ff.

inaction of the emotional subject. Like a charmed bird, the emotional person seems to be unable to get around his difficulty, unable to avoid it, and unable to solve the situation. He ought, we feel, to do something. A new adaptation is required. Either he should modify the outer world or modify himself. In such a case it frequently does help him to tell the story to some sympathetic listener. The bare telling seems to reorganize the whole setting. Perhaps it is a matter of seeing the situation through another's eyes. Perhaps it is a suggestion for a solution that reinforces some feeble impulse of the story-teller. Perhaps it is a matter of being forced to face clearly, and to organize and assimilate what has been shunned and dimly (if painfully) perceived before. Many of us have experienced the genuine escape which such a recital has afforded.

An unpleasant task, which we postpone, offers an additional suggestion. All the while we are postponing it we carry it about with us, as a disagreeable burden. At odd moments we spend an amount of time thinking about it and making futile reactions of one sort or another. In such a case the doctrine of expression, which here amounts to nothing more than the advocacy of a direct attack upon the problem, is certainly a sensible one. But here again it is not mere expression, but the solution of a problem, the bringing to an end of futile and random activities, the achievement of a definite point of view, the release of our energies. The other course is an energy-sapping one. We cannot recuperate our energies, relaxation is impossible. In such an instance the early and active attack upon the problem is the most effective way to conserve energy, and escape the energy-depleting fretfulness and attendant emotionality.

James's Statement of the Problem.—One additional question needs clarification before we dismiss the problem of expression. William James, whose theory of emotions led him to look upon the bodily state as primary and emotional consciousness as a reflection of such a state, suggested that the problem of control of emotions ought to be a problem of controlling this bodily state. In so far as we can manage the musculature we should be able to manage our emotional consciousness. Thus:

Refuse to express a passion, and it dies. Count ten before venting your anger, and its occasion seems ridiculous. Whistling to keep up courage is no mere figure of speech. On the other hand, sit all day in a moping posture, sigh, and reply to everything with a dismal voice, and your melancholy lingers. There is no more valuable present in moral education

than this, as all who have experience know: *if we wish to conquer undesirable emotional tendencies* in ourselves, we must assiduously, and in the first instance cold-bloodedly, go through the *outward movements* of those contrary dispositions which we prefer to cultivate. The reward of persistency will infallibly come, in the fading out of the sullenness or depression, and the advent of real cheerfulness and kindliness in their stead. Smooth the brow, brighten the eye, contract the dorsal rather than the ventral aspect of the frame, and speak in a major key, pass the genial compliment, and your heart must be frigid indeed if it do not gradually thaw![1]

Thus does Pollyanna find an eminent supporter.

Now, while one can see how "stopping to count ten" will give time for second thoughts to arise (and second thoughts may be wiser), there is no scientific basis for the belief that striped-muscle postures are so efficacious, in general. If this general doctrine of whistling to keep up courage is no mere figure of speech, then sad indeed must be the poker player who hides his awareness of the royal flush beneath a doleful face, and happy indeed the young man at the reception who preserves a perfect Cheshire grin above the sharp, starched points of his dress-shirt collar. True, a cheerful person is more pleasant to live with. Undoubtedly he will receive from his fellows, in return, a different set of stimuli. But apart from this social reflection of his attitude there is probably not the slightest truth in this purple passage from James. It is excellent moral counsel, questionable psychiatric advice, and unfounded psychological theory. Postures may cover up an inner tension; they do not "canalize" the tension, nor do they alter the world to which the individual must adjust.

3. *Suggestion and Autosuggestion.* ENTHUSIASTIC CLAIMS.—If one could accept, as reliable instances, the remarkable tales which crowd the literature of suggestion and autosuggestion, one would feel that here indeed is the crux of the whole problem of control. From the Hindu fakir who seems to have completely put to rout all claims of the flesh, from the remarkable cases in which hystericals have manifested the stigmata of Christ (as St. Francis is said to have done), from scattered reports of individuals who have been able to modify and even to stop the beating of the heart, from all these and countless other cases comes evidence of a direct control over

[1] James, William. *Principles of psychology*, II, p. 463. New York: Holt, 1890. Reprinted by permission of the publishers.

the automatic processes of the body. A physician reports that a bread pill can be made to act as a purge when proper suggestions accompany its administration. A nurse reports that a salt-water hypodermic is as effective as morphine when the experienced patient is unaware of the substitution. And from all these instances one is tempted to proceed, uncritically, to the assumption that the powers of suggestion are almost unlimited, that if one were only to control the *mental* state, the bodily-emotional-visceral state (ordinarily so recalcitrant) could be made to fall into line.

Thus, a follower of Coué argues that, just as we can recall a forgotten name by thinking over all the circumstances connected with our experience with the person, until finally the name pops out in full bloom, just so, by counting our many blessings one by one (in consciousness), or by affirming our powers, itemizing possessions (which may not in fact be existent now), we can produce the power and joy which now we lack.[1] The expectant listener at the trysting place hears a footfall again and again, when no footfall is there. The suggestible medical student experiences the whole list of symptoms as he studies disease. Stuttering has been known to come from association with stutterers. Why can't we put these forces to work *for* us, in the interest of self-control?

CONSIDERATION OF THE EVIDENCE.—Before we attempt to account for such phenomena it might be well to make sure that all of them are true. Like the curative powers of the grotto at Lourdes, they may be grossly exaggerated. The most obvious fact of all is often passed over, namely, that nearly all of us do *not* have direct control over the heart rate; the striking quality of the illustrations is evidence, in itself, that they are not typical. Either the cases in the literature are not well authenticated, or they are exceptional and abnormal individuals, or—and this is entirely possible—most of us are uninstructed in the technique of suggestion.

The work of Pierre Janet is, to me, the most convincing single argument in favor of the first two interpretations. Here is a man who has won an enviable international reputation for his pioneer work in the field of psychotherapy. From some of his colleagues he has earned criticism because he has made too much of suggestion. And yet Janet writes that in 3,500 cases which have come under his treatment approximately 250 (roughly 7 per cent) have yielded to

[1] Baudouin, Charles. *Suggestion and autosuggestion*, pp. 64–90. New York: Dodd, Mead, 1921.

suggestion.[1] When one considers the credulous attitude with which most of us approach our physician, and when we remember in addition the eminence of the man giving the suggestions, does it seem credible that we shall ever make much progress in fooling ourselves with the puerilities of New Thought, Couéism (and, one should add, of Christian Science)? The fact which we should remember is than an eminent scientist, himself not hostile to the method of suggestion, employing the state of extreme suggestibility known as hypnosis, was unable to induce a cure in six-sevenths of the cases where it was tried.[2] It would seem to follow that the method is condemned out of hand, for the rest of us. This is particularly true of the version known as autosuggestion, wherein the subject supplies the suggestions to himself and thus, mentally, seeks to lift himself by the bootstraps. For, after all, the suggestions which come to us from others are much more potent than those which we supply ourselves. The genial compliment of another cheers us more than our own verbal pat on the back.

Autosuggestion vs. Rational Planning.—The fact is that an enthusiastic espousal of autosuggestion is itself a serious mental symptom. It is not a healthy sign, in our world, that one should wish to live in this fairy land of words, and wishes, and make-believe. Aladdin's lamp, grownups ought to know, occurs only in the realm of fancy. It is appropriate to the age of innocence and fairy tales, or to primitive races; not to civilized adults. Adults should know that the most effective responses within the equipment of an individual lie within the realm of social action. It is the reflection of our action from the social mirror, held up by our supporting group, that moves us most profoundly. So our counsel to the one who dabbles with suggestion should be: Suggest your worth to yourself by so acting that the group you respect most highly may *see* that you are worthy. The insane asylum contains many "queens of the universe" and "kings of light." Their verbal patterns are not worth much, out of touch with social reality as they are.

All this does not mean that "taking thought" is of no avail. When one pauses to consider his emotional problem in a rational manner he may discover some solution, some new aspect of the

[1] Janet, *op. cit.*, Vol. 1, p. 361.

[2] It goes without saying that Janet did not attempt to employ the method in cases of ailments such as cancer, diabetes, tuberculosis, but dealt entirely with complaints where psychotherapy was in order, a distinction which Christian Scientists disdain to recognize.

problem that will be as effective a release as though the solution were an accomplished fact. But this type of thinking differs radically from the mumbo-jumbo of the cults of autosuggestion, which, however devoutly they may be pursued, amount to little beyond the affirmation of wishes.

Classifying the Stimulus.—For this reason one is inclined to be skeptical of the method of "classifying the stimulus" proposed by Professor Pillsbury.[1] It is argued, for example, that "whether a remark falls into the group of jests or of insults is often largely a matter of chance, and dependent upon circumstance. The emotions may be controlled only in so far as it is possible to vary the classification of the stimulus." When the sentimental movie is about to make an assault upon your lachrymal glands, and you consider the probable remarks of your companion when the lights are turned up and your red eyes are visible, you may proceed to classify the stimulus. "Don't be silly," you say to yourself, "this is only a movie. I wonder how much a week she gets for doing that. Do you suppose those are real tears, or is it glycerine, or does she use an onion, as I have heard?" Or you picture, in imagination, the director bawling through the megaphone, or you search for probable sham items in the setting.

Or, since we are seldom insulted by the remarks of the child, it is urged that with adults we try the method of "considering the source." We preserve our equanimity in the face of the physiological specimen brought to class, why shouldn't we be equally calm in the face of the bloody accident? What we see can be described in the vocabulary of physiologist and the anatomist. So surgeons deal with "cases" and teachers must deal with pupils "in the lower tenth," etc.

The instructor in surgery knows much better, however. He knows that in spite of this "very professional attitude" which the young medical student has assumed giddiness and nausea will seize him when he least expects it. The hard-boiled and professional attitude of the older practitioner is the outgrowth of long experience. He has been so conditioned that there is no *need* of any verbal ritual. And the youngster without the experience will find that the formula is worthless. It is this "conditioning" which is the crux of the matter.

[1] Pillsbury, W. B. *Essentials of psychology*, p. 335. New York: Macmillan. 1930.

Alfred Adler, the Viennese psychoanalyst tells the story of three small boys who were taken one at a time, to see the lion at the zoo. One, with evident fear and trembling said, "Isn't he beautiful?" The second, likewise disturbed, said, "May I spit at him?" The third, a very matter of fact young person, said, "We will go home."

Of the three attitudes, the third is probably the frankest and the nearest to a rational solution. Whether the autosuggester attempts the "sour grapes" mechanism of belittling the stimulus or a combination of Pollyanna and Emile Coué, the immediate effect is probably the same.

4. *Health and Regimen.*—We have commented earlier upon the physician's error in dismissing emotionally caused disorders as imaginary. It is equally true that the mental hygienist can commit the complementary error of assuming that all emotional cases are basically psychological problems. Dr. Hamilton found that many of his cases involving emotional problems were at basis matters for the physician. The original impairment of the individual was physical, physiological. Dr. Pierre Janet writes, "most neuropaths are depressed or *exhausted* persons."

It therefore behooves us to secure a "clean bill of health" before we raise the psychological problem. And beyond the physical condition there is the regimen of work, and rest, and play, which must be considered. It has long been recognized that sheer bodily fatigue has a great deal to do with our emotionality. We are irritated and vexed, when fatigued, at the questions of the child, whereas when we are rested they amuse us and we are interested in answering them. "The last straw" is presented by the problem which we meet when our reserves are exhausted. Those who spend continually beyond their physical resources may expect, as symptoms of their physical bankruptcy, continual emotionality. It is true that no simple rule of thumb can be evoked here; the appetites for adventure and excitement, the physical reserves of energy, the margin of safety which permits some to endure energetic activities far beyond the normal amount (with little or no aftereffect), all vary widely from individual to individual, and must be studied anew in each case. The emergence of the emotionality should raise the question of regimen, however, for it is frequently a symptom that the boundaries have been surpassed.

While such generalizations are of limited worth, we are frequently reminded that modern life is subject to just this type of bankruptcy.

At one time the European psychiatrist was inclined to posit a kind of "Americanitis," feeling that a hectic, frantic, and disorganized type of living characterized the American scene. One sees evidences of the symptoms on the college campus, and frequently the "infirmary" is used by those whose energies have become momentarily bankrupt, as a convenient place for recuperation.[1] University life, instead of being cloistered, as it may have been at one time, is now stepped up to a most rapid tempo. The student feels that he has no leisure in which to read the things he would enjoy. It sometimes seems that the professors jealously compete for a student's time, each extending his own assignments so that they will claim a fair proportion of attention. The college calendar is crowded with committee meetings, lectures, entertainments, dances, football games, etc., until both faculty and students feel subject to that fine frenzy of haste. It is true, on the other hand, that both faculty and students manage to waste a fairly large proportion of their time, but usually under far from the most restful of conditions. The competitions for place, which we are most likely to associate with the business and professional world outside, are here too. There is competition for grades and honors among the students; and the faculty experience the pressure for publication and research.

If, with energy depleted, the flood of stimuli persists, emotion results. Our "level" of responding has dropped, and with the onset of fatigue our discriminations and delicately adjusted perceptions fail us. Unable to assemble the complicated responses which are demanded, we can only respond "en masse." The emotions, like the primitive reverberations that they are, are reached now that the skilled skirmishers are no longer on guard. Alert, and rested, our reaction systems are assembled and integrated at high speed. We are able to "take care" of the stimuli. Fatigued, exhausted, with a sluggish, toxic system, the stimuli are too much for us, and we "emote."

When emotionality springs from these types of energy depletion one would recommend:[2]

[1] Since such periodic rests are not openly legalized, frequently the exhausted individual has to "cook up" an illness to justify his (or her) admission.

[2] The reader desiring a complete discussion of the problem will find Janet's *Psychological healing*, Vol. I, Part III, dealing with *Psychological economies*, most satisfactory.

A simplification of the environment
A reduction of the number and the difficulties of the decisions forced upon the individual
The establishment of hygienic routine, with a proper balance of rest, work, and play
The restriction of "expenditures" (of energy) to the limited budget of the exhausted person
The utilization of various relaxation techniques.

5. *The Liquidation of Traumatic Memories.*—In Dr. Hamilton's case of claustrophobia (Case 2, p. 294, described as "conditioned fear reaction") we saw how earlier experiences could leave their stamp upon the behavior of a person without the individual's recognition of the nature and cause of his difficulties. Frequently the subject may be unable to give any plausible account of the origin of his affliction. It is as though a memory of the past event were present and active, but somehow split off from those verbalizing, recalling reactions which we call consciousness. He is aware of his difficulties, but oblivious of their origin. He is like the unconscious plagiarist who repeats a witty remark that he has heard, thinking that it is one of his own invention.

The Freudians have elaborated a system of psychotherapy upon the basis of their experience with such cases, and we shall have to consider their system later on; but for the moment we shall do well to confine ourselves to the objective facts in the case. Dr. Hamilton, aware of the nature of such traumatic memories, and unable to discover any factors in the patient's present condition which could account for his periodic disturbances, sought to probe for early experiences which might account for the unusual behavior. Failing in the direct methods, he instructed his patient in the method of "free association" and told him to practice it in the evenings when completely relaxed.[1]

[1] In the free association method of analysis, a fragment of the experience to be analyzed is selected, and the subject is instructed to react to it freely with the first word or thought that occurs to him. He is urged to discard nothing as irrelevant or inconsequential; to admit to consciousness whatever occurs, the trivial, the obscene, the fantastic, etc. In short, he is urged to "free his mind from all censorship." Since one thought leads to another, he is to allow the trail of associations to unwind. The theory back of this procedure asserts that the dissociation of consciousness is in the first instance due to repression. The relaxed and "uncensored" type of recall, it is believed, is calculated to furnish clues to that which has been "put out of mind."

Dr. Hamilton's patient called him a few days later to tell him that he had recalled the childhood episode that was responsible for his difficulties. In spite of his physician's desire to pursue the analysis and study subsequent developments, the patient was not seen again. The implication is that the revival of the "lost" memory accomplished the cure.

In his *Psychological healing* Janet describes four cases which are similar to the one we have considered, and he expresses the opinion that his records will show at least fifty cases where severe afflictions of a similar order are amenable to the analytic type of cure. Drs. Kessel and Hyman[1] report that in twelve years of medical practice, out of thirty-three cases referred to analysts, five were clearly cured by the analytic technique alone, and eleven others were helped. As the process is described in the particular case we have selected, the elimination of traumatic memories is very simple. The physician was not even present, at most a few hours had been involved, and the mere awareness of the causal event eliminated the symptoms.

How can this be possible? Various suggestions are offered. It is argued, for example, that dissociated ideas (or habits) develop without the restraint which would normally exist. The "whole person" is not involved, for the dissociated act is like an automatic reflex. To apply this conception to our example, this man in his forties is no longer afraid of raccoons—he has long ago put away childish things. But so long as the fear is "nameless"—a fear of some terrible impending catastrophe—he cannot apply the corrective of his adult habits. The moment he realizes the nature of his fear, however, it disappears.

The explanations are likely to be figurative rather than physiological, functional rather than mechanistic; for the truth of the matter is, we do not have any adequate physiology to cover the facts. The Freudians, as we shall see later, have invented a very special psychology of their own, for the most part entirely divorced from any physiological considerations. For the Freudians the traumatic experience is usually sexual, the damage is committed in the repression of the libido (sexual or vital force), and the symptoms are a figurative conversion of psychic energy into physiological

[1] Kessel, Leo, and Hyman, Harold T. The value of psychoanalysis as a therapeutic procedure. *J. Amer. med. Ass.*, 1933, 101, 1612–1615.

states. In spite of elaborate theoretical constructions, this method of cure remains something of a mystery.

The method has distinct limitations, apart from the fact that it has not been found to work in a large percentage of the cases where it has been tried. In spite of its apparent simplicity, as Dr. Hamilton's example would suggest, the average "analysis" lasts sixteen months.[1] Its costliness ($200 to $5,000) is prohibitive for many people. It is found to be more applicable to those younger than forty, and to those with trained intelligence (professions, arts).

Contrary to a few enthusiasts who seem assured that specific and dramatic mishaps can always be found (and within a limited field), it is the opinion of more conservative psychiatrists that such simple and dramatic solutions are the exception rather than the rule. The final stage of anxiety, exhaustion, and depression may be reached as the culmination of a multitude of infinitesimals. Multiple causation is the rule.

6. *The Method of Reeducation.* THE POWER OF WORDS.—As we have indicated earlier, so few of our emotions are "original" in the sense of being instinctive and innate, and so many are matters of conditioning and training, that we naturally turn to some method of reeducation when we consider the problem of emotional maladjustment. Excessive emotionality, like "finicky" tastes in food, may spell faulty education.

Now, man is to such a notable degree a social animal that he turns easily to words in solving his problems. From the primitive medicine man who cured by casting out demons to the twentieth century preacher who exhorts us to seek salvation, with words, man has been addicted to word magic. Paul Dubois, of Berne, founded a school of psychotherapy that rested at basis upon sound moral counsel; he sought to strengthen the will and character of the subject through verbal rituals. Both the ritual of "confession" and the practice of psychoanalysis utilize these same methods. The many "purple passages" in William James show that this psychologist and philosopher had faith in similar methods.[2]

Teachers, preachers, artists are all trying to shape the human spirit, to make it vibrate to their words. One senses the strong moral current running through such a work as Thomas Carlyle's

[1] *Ibid.*

[2] James, William. *Principles of psychology*, Vol. I, p. 126. New York: Holt, 1890.

Heroes and hero-worship. Indeed, is not all inspirational literature precisely a form of word magic? And words *do* move men. Who will say that the words of Jean Jacques Rousseau did not accelerate the changes which followed in Europe, or that the words of Lenin were a negligible factor in the Bolshevik success in Russia.

But not all of us possess this power of words in any measurable degree. At its highest, and when it is most moving, word magic merges with art; in its humblest and most prosaic form it consists in well-meant suggestions and good advice. We try to talk our friends out of their fears and depressions; we try to endow them with more energy than they possess, to interest them in what is really a matter of indifference—with indifferent success. After all, they have words too, and it is their view of the world against ours. Even when they are prepared to give intellectual assent to what we say they confess that they do not "feel" the truth of what they rationally must admit. We do not touch the core of things, we fail to impress, and they remain much as they were before. Circumstances are more powerful than our words.

THE WEAKNESS OF VERBAL METHOD.—And so we find that where the method of verbalization is systematically tested, as, for instance, in the nursery school, it has distinct limitations. Obviously it cannot be used with the very young, for words have not yet acquired their full force. In the beginning they are but part of that buzzing, blooming, confusion which surrounds us all. Even at five, when words have definite values for us, they are not a very successful tool in emotional reeducation. Mary Cover Jones[1] reports the case of a child who developed a fear of a rabbit. This child, in her fifth year, was given daily "doses" of conversation about rabbits. Peter Rabbit stories, toy rabbits, pictures of rabbits, plasticine rabbits furnished material around which the verbal treatment centered. Then, at the end of the week, the rabbit was introduced once more. The fear reaction had persisted. While this single experiment affords too slender basis for generalization, when taken with adult experience which is all too similar, one is inclined to see in it simply a special instance of what commonly happens when we separate "theory" and "practice." We become ritualistic in religion; we do "lip service" to democracy in politics—our words are all too easily divorced from our actions. And the psychotherapeutic moral

[1] Jones, M. C. Elimination of children's fears. *J. exp. Psychol.*, 1924, 7, 382–390.

would seem to be that only in so far as they are able to initiate overt attempts at a new adjustment can words function as useful tools in the reeducation process. Verbalization by itself is worthless. After all, it is not a word world in which we live, and our reeducation should be directed toward that world of objects to which we must finally adjust.

THE METHOD OF DISUSE.—A second method of reeducation frequently proposed is the method of disuse. Truly speaking, it is not a method of reeducation at all, but merely a polite term for putting off such reeducation. "Let him alone. He'll outgrow it," is often heard, and where there are overanxious and possibly nagging parents and friends it may represent wise counsel; but whether or not he outgrows it will depend largely upon what happens to him in the meantime. Again, the nursery school experiments yield negative results. We do outgrow many of our fears; but it is an open question as to whether mere lapse of time has anything to do with it. The hysterical phobias which have persisted through several decades without any real reinforcement suggest that time alone is a poor reeducator. Something might well be done in the meantime.

THE METHOD OF REPEATING THE STIMULUS.—A third method suggests that we "wear out" the reaction by repetition of the stimulus. Is the child afraid of the rabbit or the swimming pool? Then we'll present him with a rabbit or swimming pool situation until he gets tired of being afraid. And to this method the nursery school results offer the following answer: Your child *may* overcome his fear; he may become quite indifferent to it. On the other hand, his fear may grow more intense, show a summation effect, and spread from swimming pool to swimming instructor, to the preparations for the swim, etc. In any case we can scarcely hope, by mere repetition, to reverse his attitude from one of fear and indifference to positive approach responses and delight in the object or activity. That is, unless more than mere repetition is involved.

In connection with this last method it is interesting to note that Professor Knight Dunlap[1] advocates a special variety of "repetition"—differing from the above description in certain important respects—as a method of correcting such habit disorders as stammering, tics, thumb sucking, masturbation, and homosexuality. The stammerer, for example, is taught to stammer *voluntarily*. Not until

[1] Dunlap, K. *Habits, their making and unmaking*, Chap. 10, pp. 194–231. New York: Liveright, 1932.

the habit has been converted from the involuntary to the voluntary classification should he undertake any practice in correct speech. Similarly, the typist is urged to type a page of his errors rather than a page of correctly typed words. Dunlap lays great stress upon the subject's *desire* to improve, upon his understanding of the purpose of the practice, and upon the importance of careful analysis and rigid standards in the performance of the error. In addition, this practice is supplemented with practice in correct speech (or whatever other habit is being handled) and with earnest efforts to discover causes, remove them, and supply the widest possible types of guidance and counsel. Dunlap is convinced, however, that in the negative type of practice (practice of errors) he has hit upon an important principle of reeducation.

As we shall see later, in our discussion of conditioning, methods of training which are superficially similar will develop inhibition in some subjects and new conditioned responses in others. Professor Dunlap has discovered a set of conditions which produce inhibition, but it is questionable whether they are fully formulated in his terminology of "thoughts, desires, and ideals." It is entirely possible that a more complete formulation cannot be made at present; but if workable directions are to be given to the clinician, it would seem that they should be formulated in the "foolproof" vocabulary of science. Professor E. R. Guthrie[1] is of the opinion that Dunlap's method succeeds because the subject, originally unaware of the cue which starts the involuntary process, becomes aware of the initiating stimulus. Thus, through training the tic or stammer becomes voluntary (*i.e.*, verbally cued) and hence subject to "verbal deflection," and he can "take it or leave it." Just as the smoker, finishing his meal or stepping out of office or classroom, has his cigarette lighted before he is aware of it, the stammerer is launched on his particular speech spasm before he has any awareness of the cues which start it. Learning to react attentively and voluntarily brings the habit under the sway of new cues and postures, and an automatism which has existed in semi-independent fashion becomes integrated with the rest of one's habit systems in a new fashion. The physiological (or stimulus-response) formulation of the problem is, however, still inadequate.

Socialized Reeducation.—A fourth method of reeducation utilizes social factors. Since many of the undesirable emotional

[1] Guthrie, E. R. *Psychology of learning*, p. 144. New York: Harper, 1935.

responses are both cued by and directed toward other persons, it is argued that the proper situation in which to reeducate a person who is socially maladjusted can never be less than a social one. No conditioning in the laboratory, no heart-to-heart counsel can accomplish what the group itself will accomplish. This does not mean that all one has to do is to turn the fearful, timid child out to play with the young ragamuffins of his neighborhood. Unregulated and uncontrolled "dunking" of the individual in the social whirlpool may make or mar. The timidity of the child, at first directed, say, toward animals, may spread to other children as they shame him. If they cry "Fraidy cat" and run toward him with snake or frog, as conscienceless youngsters are wont to do, his social reeducation can provide nothing but bigger and better maladjustments. And so the supervisors of the nursery school or the playground must act as governors, behind the scenes as much as possible, but nevertheless fully in control. The shy one must be brought forward, and the overaggressive one taught to follow as well as to lead. It is not so easy to create such groupings for the older "children," the maladjusted adults, but the counselor who would help them correct undesirable and socially crude emotional reactions must turn his thought in this direction. Much of the pathology of character is social in origin; it is but natural that it should demand a social therapy.

Simple Conditioning.—Simpler situations, where all the items are within control, offer dramatic and convincing proof of the possibilities afforded by the method of reconditioning. Following the method of Pavlov (who induced salivation in response to buzzer, touch, metronome, etc.), may we not attach desirable emotional responses to the situation which is feared? In our formula

S_1 . . . . R_1
(rabbit) (fear, sympathetic dominance)

↘

S_2 . . . . R_2
(lunch, high-chair etc.) (quiescence, "comfort," cranio-sacral dominance)

which serves to symbolize the conditioning process, may we not let S_1 represent the stimulating situation which arouses the response with which we are concerned, and S_2 represent a sought-for condition

which will produce an antagonistic and prepotent reaction of a more desirable type. Thus Watson describes the reconditioning of the boy Peter who showed a pronounced fear of a playroom rabbit. In Watson's words:[1]

> We did not have control over his meals, but we secured permission to give him his midafternoon lunch consisting of crackers and a glass of milk. We seated him at a small table in a high chair. The lunch was served in a room about 40 feet long. Just as he began to eat his lunch, the rabbit was displayed in a wire cage of wide mesh. We displayed it on the first day *just far enough away not to disturb his eating.* The point was then marked. The next day the rabbit was brought closer and closer until disturbance was first barely noticed. This place was marked. The third and succeeding days the same routine was maintained. Finally the rabbit could be placed upon the table—then in Peter's lap. Next tolerance changed to positive reaction. Finally he would eat with one hand and play with the rabbit with the other, a proof that his *viscera were retrained along with his hands.*

This method calls for ingenuity on the part of the experimenter at two points. In the first place, he must provide a situation which will evoke an antagonistic (and desirable) reaction in sufficient intensity and, in the second place, he must discover a method of presenting the emotion-inciting stimulus (in this case the rabbit) in "doses" so weak that the undesired reaction will remain weaker. If this latter condition is not fulfilled, the undesired reaction may easily spread to the new elements which are paired with it, and as in our illustration, the midafternoon lunch, the high chair, and even tying on the bib may become cues which will excite a fear reaction. In Hamilton's case the fear induced by the automobile accident had spread to a wide group of stimuli associated with the street, even to stepping out the front door.

Thus, the child who has been badly frightened, or who has repeatedly failed in a certain situation, must be led up to the scene of his previous defeats gradually, and unless one wishes to risk further defeat and a serious setback, the hurdles must be such as can be easily cleared. The defeated child needs a guarantee of success and safety. Nor are the conditions for adult education different in principle. One is reminded of the techniques commonly employed to get the pupils in the swimming class over their fear of the water;

[1] Watson, J. B. *Behaviorism*, New York: People's Institute, 1925. pp. 129–130. Reprinted by permission of the publishers.

for example, ducking first the face and then the head under water, doing the dead man's float, etc. We try to demonstrate to beginners, in all sorts of situations, that they have *full control over the situation* and that it may be touched, approached, and handled without unpleasant consequences. One of the strongest arguments for the classification of pupils in the public schools lies in the fact that the retarded child may have a chance to meet hurdles commensurate with his ability, and in competition with his equals discover that he can occasionally succeed. The result of such classification is that the child who has lost interest through repeated failure, and who has presented a serious discipline problem through his various compensations for his inferiority (gaining attention and notoriety through his mischievousness, or bullying, or defiance of his teacher), frequently discovers an interest in what had previously bored him and abandons his antisocial behavior.

Improving One's Habit Equipment.—There is another sense in which methods of reeducation may attack emotional problems. It has already been pointed out that emotion frequently arises because of conflict and because of the insufficiency in our habit equipment. Our embarrassment in a social situation may arise simply because we do not know what to do, or how to make small talk, or what to expect, and we see our embarrassment vanish as experience fills in these gaps. Our flustered state, on first learning to dance, gives way to the pleasure of making rhythmic motions to music, as we learn the steps, and how to hold and guide our partner. The young man at the box-office window who is forced to make change rapidly, locate tickets, with a speed and accuracy sufficient to keep the line of customers moving, is excited, nervous, emotional when he first tries the job. An evening's work is exhausting. But when the coordinations are well established and the customers' demands can be easily and rapidly met, the emotional element disappears. The whole affective tone may be reversed.

Education in Relaxation.—Jacobson believes that many emotional conditions can be successfully treated by teaching the patients how to relax. He writes:

In my own observations, reports have been secured independently from subjects and patients under normal conditions as well as during states of nervous excitement. They agree that the emotions subside as the individual *completely* relaxes the striated muscles, particularly those which he seems to find specifically concerned in the emotions at hand: the esopha-

gus in one instance of fear; the forehead and brow as a rule in worry or anxiety. As a further test during emotion, the instruction has been given to relax completely yet retain the emotion. When this was done without intimation by the experimenter of possible result, all highly trained subjects independently reported it impossible to carry out the double instruction. They found it impossible to be emotional and relaxed at the same time.

Accordingly, present results indicate that an emotional state fails to exist in the presence of complete relaxation of the peripheral parts involved.[1]

Thus described, the view of Jacobson appears as simply another version of James's advice to "smooth the brow" and "contract the dorsal rather than the ventral aspect of the frame"; but Jacobson's advance lies in the description of a definite technique for achieving this complete relaxation. Varying in length from a few hours to many months, Jacobson has found it beneficial for cases classified as nervous hypertension, insomnia, anxiety neurosis, tics, esophagal spasm, hypochondria, stuttering. As to the theory underlying his technique, it is apparent that Jacobson believes that "the subjective experience of emotion is largely derived from intensive proprioceptive impulses" and, hence, in voluntarily relaxing the striped musculature the energy stream responsible for the affective state is shut off. Apart from this theory, it is evident that tense muscles will be more irritable and will certainly intensify any state of "upset." In attacking the skeletal patterns, too, Jacobson is utilizing the portion most easily brought under control. But whether this modern version of a very ancient oriental practice can accomplish all its enthusiasts would claim for it may be doubted. Its chief drawback lies in the fact that it is an attack upon the expression or symptom, upon the end product of the emotion-producing situation, rather than upon the situation itself or the individual's habits of responding to it. As a substitute for drugs it has decided advantages, but other methods of treating emotional maladjustment promise a much more effective type of relaxation. Moreover, it is precisely the emotion-producing crisis which does not allow us to relax. As well tell the patient with a jumping toothache that it will disappear if he relaxes completely as to advocate the muscular

[1] From Jacobson, Edmund. *Progressive relaxation*, pp. 217–218. Chicago: Univ. of Chicago Press, 1929. Reprinted by permission of the publishers.

relaxation method of Jacobson as a universal method of treating emotions.

Concluding Note.—Perhaps it is well that each of the methods suggested has limited applicability and that the problem of control is not simple. If the emotions were too easily handled we should become apathetic creatures, able to live with and tolerate situations which should be rectified. As it is, the emotional stimuli mobilize the energy with which we meet and master our serious obstacles; keep us "toned up" and with a zest for living; and they arouse that needed biological protest which drives us to shape this world nearer the human heart's desire.

CHAPTER VII

MOTIVATION

The Problem: from Reflexes to Purposes

Human beings are such strange and baffling creatures that a psychology which attempts to understand them in their entirety is, indeed, an ambitious science. Their purposes and motives are infinitely varied, and they are such restless, dissatisfied, striving creatures that any attempt to reduce their chaotic impulses to law and order seems to risk certain defeat at the outset.

The reflex-arc concept has provided a basic physiological insight; but when we follow it exclusively the resultant picture of behavior not only violates our *amour propre*—it seems inadequate. We are not merely a collection of segmental reflexes; we respond as a unit. And man is more than a passively reacting machine; he acts upon his environment, re-creating it and fashioning it nearer to his desires. The more we reduce behavior to a set of reflex twitches the more we shall be prompted to add some governing intelligence behind these units. Where shall we place any integrating, purposive force in a physiological system that operates along reflex principles?

One type of solution has been examined, and our study of the problem of instinct has warned us against positing forces which, all too often, turn out to be little more than reified names. These magical names explain nothing, and if we are to avoid the pitfalls of the naming fallacy we shall have to seek the answer to the riddle of motivation elsewhere than in the libido, the instincts, an *élan vital*, or some mysterious neurokyme which impels us to action.

Motivation as a Problem in Energetics

The Chemical Sources of Energy.—The forces which drive the body levers originate in the food we eat, the air we breathe, in the energy of the sun's rays. To an extent, therefore, human behavior presents problems which can be duplicated in the internal combustion engine, and if the human engine seems to be peculiar in its self-stoking properties, we at least need not turn to some peculiar

source of energy to explain its motion. The vital force, we now believe, is ultimately reducible to the same atomic sources which are considered in the fields of chemistry and electricity. Without denying the uniqueness of the arrangements that constitute the human mechanism, and without denying its peculiar properties, we at least need not invoke a special explanation for its activity.

As surely as this is true we may expect to find chemical and physiological explanations for variations in motivation, or as it is often referred to, in *drive*. One individual will be possessed of abundant energy, and will be able to work against obstructing circumstances and the onset of fatigue, whereas another will speedily tire and give up the struggle—all because the metabolic machines of the two operate with different levels of efficiency. The child will romp and play and display an excess of motion that is almost tiring to the onlooker, and when he falls asleep, seemingly exhausted, a brief rest restores him and he is ready to start out again. The adult, recovering from energy expenditure at slower rates as the years go by, learns to husband his energy and to accomplish thoughtfully—with energy-conserving skills—what was earlier done with reckless abandon of consequences. The change in motivation with the onset of age is thus in part a matter of body chemistry. Disease, with its toxins and fevers, disturbances of digestion or of the glandular catalysts which regulate the rate of metabolic change, will also produce fluctuations in the delivery of energy and alter the thresholds of the responding mechanisms.

Changes in Activity Level.—Even under constant external stimulation the healthy organism shows rhythms of activity which are traceable to the underlying energy-supplying equipment. One of the clearest examples of the ebb and flow of activity, in this case traceable to the ovarian hormone, was shown by Wang,[1] who studied the female white rat. Cyclometers attached to rotating chambers, resembling the "squirrel cage," recorded the number of revolutions daily, and when the results were plotted the "activity curve" showed a four-day rhythm. The peaks of the curve corresponded to the "receptive" phase of the oestrous cycle. At such peaks the female received the advances of the male, and microscopic examination of the epithelium of the reproductive tract also gave evidence that the rhythm involved the whole reproductive mechan-

[1] Wang, G. H. The relation between "spontaneous activity" and oestrous cycle in the white rat. *Comp. Psychol. Monogr.*, 1923, 2, No. 6, 27.

ism. Proof of the glandular basis of the cycle is given by the facts that it does not appear in either male or prepubescent female, that it emerges with puberty, that pregnancy and lactation interrupt it, and that it disappears with removal of the ovaries.[1]

One interesting illustration of the role of the underlying energy stream is afforded by an experiment by Skinner,[2] who also used a running wheel as a measure of activity. He found when adult rats are so restricted that overt activity is cut down during a portion

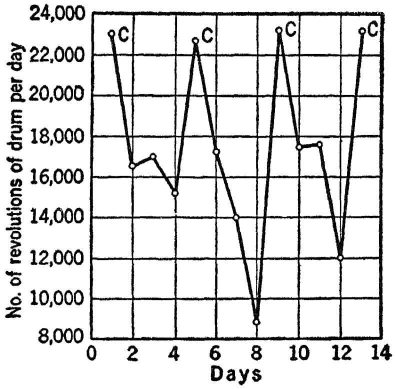


FIG. 57.—Rhythms of bodily activity corresponding to oestrous cycle in a female rat. Examinations were made at each encircled dot. At those marked *C* cornified epithelial cells were found indicating that the animal was "in heat." Abscissas, days; ordinates, number of revolutions of activity drum. (*From G. H. Wang. The relation between "spontaneous" activity and oestrous cycle in the white rat. Comp. Psychol. Monogr.*, 1923, 2, No. 6. Pp. 27. *By permission of the publishers.*)

of the day activity in the remaining portion tends to be greater. The continuing processes of metabolism have produced stores of combustibles, and these in turn guarantee irritable response mechanisms. There is thus a chemistry to the exuberance which follows release from certain types of "repressing" conditions. The laughter, shouts, maulings, and general horseplay of youngsters released from classroom confinement are symptoms of the accumulated energy;

[1] In an attempt to induce the four-day rhythm in male rats by transplanting ovaries into the bodies of castrated males, 17 out of 24 animals showed an increase in general activity level, and 4 subjects showed the characteristic four-day cycle of the female. Wang, G. H., Richter, C. P., and Guttmacher, A. F. Activity studies of male castrated rats with ovarian transplants, and correlation of the activity with the histology of the grafts. *Amer. J. Physiol.*, 1925, 73, 581–598.

[2] Skinner, B. F. *The behavior of organisms*, p. 364. New York: Appleton, 1938

and the recess which allows them to "blow off steam" is more than a rest and diversion—it simplifies the discipline problem for the succeeding period.

Levels of Energy Output and Types of Overt Adjustment.—The whole endocrine-autonomic background for our activity may be conceived as supplying an energy stream, now gushing with tidal force, now at low ebb. Causes as widely separated as malnutrition, hypothyroidism, adrenal insufficiency, and experimentally induced anoxemia may so lower the energy output as to produce the symptoms of neurasthenia (nervous exhaustion) and other abnormal states in which the positive drive, the outward thrust of behavior, seems lacking. When these states are chronic the individual may show his ineffectuality in fretfulness, persistent worrying, sense of inadequacy and inferiority, and, instead of the direct attack upon difficulties displayed by the person with stamina and an abundant supply of energy, he may utilize his small reserves in achieving a peevish control of those in his immediate family or in fanciful flights away from reality into dreamworld solutions. While the low ebb of the energy stream is not a sufficient explanation of the patterns taken, it must be borne in mind as a predisposing factor which renders the normal, more extroverted and more energy-consuming solutions difficult.[1] Unquestionably many of the character traits of the aged are rooted in the depleted energy stream, and those who achieve serenity in their declining years are forced to adjust to this basic fact.

The energy-releasing aspect of our emotional responses has already been commented upon. Cannon and others have abundantly demonstrated the details in the process whereby our emergency emotions release the reservoirs of stored energy, and these sudden fluctuations in available energy, with the variations in irritability and responsiveness accompanying them, must be included in our view of motivation as a problem in energetics. The sudden access of "will" in response to an insult or challenge thus proves, in part,

[1] Concerning schizophrenia, where "shut-in" traits are most prominent, Dr. R. G. Hoskins writes: "Our own studies point toward the conception that the most fundamental metabolic characteristic of this psychosis is defective oxygen-assimilation." Chap. 11, Endocrinology, in *The Problem of Mental Disorder*, a study undertaken by the Committee on Psychiatric Investigations and edited by Madison Bentley and E. V. Cowdery. National Research Council: Committee on Psychiatric Investigations. New York: McGraw-Hill, 1934.

to be a matter of the release of stored glycogen, increased ventilation of the lungs, and a resulting heightened muscular tonus and irritability. What we describe in molar-psychological terms as "determination" appears on a neuromuscular level as heightened irritability, increased tonus, lowered thresholds of response, and on a chemical level as increased metabolism. It is as though the stimulus, like the thermostat control of an automatic stoker, started the fuel feed and opened the draft.

Activity Levels and Food Intake.—It is not surprising that the fluctuations in general activity should show some relation to food intake, since this is the principal source of the energy displayed. It is noteworthy, however, that in this case—as in the case of thirst—the peaks of expenditure are associated with *depletion*. Thus, the curve of activity portrays a neatly compensating mechanism which, at least in the experienced animal, operates so as to maintain the store of available energy. Richter demonstrated this in rodents by means of an activity cage so mounted on tambours that each movement of the animal was recorded on a kymograph drum.[1] When their responses were tabulated in the form of a curve he found that their activity fell markedly following eating and rose again just before the next feeding period twenty-four hours later. An intermediate zone of moderate activity was shown some four or five hours after the first feeding. Since the same curve was found when illumination was controlled and when the time of feeding was shifted to different times of the 24-hr. day, he was able to show that the activity curve depended upon the feeding cycle. The increase in irritability and the release of energy parallel those foraging activities which are necessary to maintain the energy level. The same type of relationship holds for thirst. In both cases, however, continuous deprivation weakens the animal; in the case of food, after two or three days the whole curve drops progressively; in the case of thirst, the peak of the curve is passed within the first 24 hr.

Other studies have shown that within the 24-hr. cycle there are bursts of activity of briefer duration which also possess a regular cyclic character. An experimental study by Powelson,[2] in which the stomachs of his rat subjects had been transplanted to a position just under the abdominal wall where the stomach contractions could

[1] Richter, C. P. Animal behavior and internal drives. *Quart. Rev. Biol.*, 1927, 2, 307–343.

[2] Powelson, M. H. Gastric transplantation. *Science*, 1925, 62, 247–248.

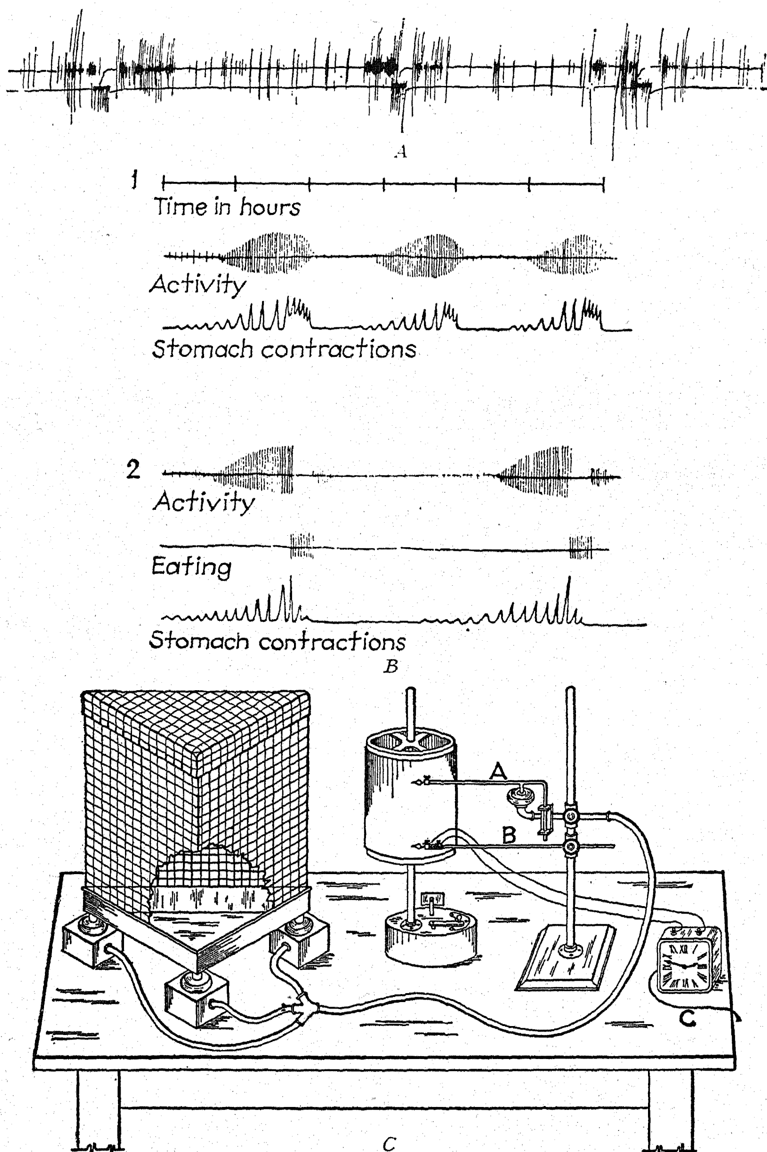


FIG. 58.—*A*. Kymograph record showing the relation between gross bodily activity and feeding period.

B. Schematic representation of the relation between periods of gross bodily activity and stomach contractions.

C. Activity cage and recording kymograph. Each corner of the triangular activity cage rests upon tambours, and the animals' movements are transmitted through the pneumatic line to the tambour (*A*). A magnetic marker (*B*) operated by an electric clock gives a time line. (*From C. P. Richter. Animal behavior and internal drives. Quart. Rev. Biol.*, 1927, 2, 307–343. *By permission of the publishers.*)

be observed and recorded, showed that the bursts of activity in skeletal musculature (exploratory activity) were correlated with contractions of the stomach wall. Wada[1] was able to show the same correlation for human subjects by means of a balloon technique. A swallowed balloon was slightly inflated through an attached tube and the latter connected with a recording system so that each stomach contraction produced a record on a kymograph drum. A subject lay upon a bed so mounted that slight movements also activated a recording marker. The parallel records showed, in both waking and sleeping states, coincident changes in the alimentary and skeletal musculature. Tests with a hand dynamometer during contractions, after a meal, and during the intervening quiescent periods yielded averages of 90.5, 83.6, 86.4 kg. respectively. Her subjects also showed, in general, superior performance in Thorndike intelligence tests during the periods of active contraction. Where continuous mental work ran through succeeding periods of contraction and quiescence, the latter were more likely to be marked by fatigue and lower efficiency. The reports of her subject who was trained to sleep under the laboratory conditions and was wakened at intervals indicate that the activity-contraction periods were likely to be accompanied by dreaming.

Relationship between Stomach and Skeletal Muscle Contractions.— The coincidence of the stomach and skeletal changes raises the problem as to the relationship of the two. It has long been known that the stomach contractions give rise to "hunger pangs" which the subject can report. Using a stomach balloon technique, Cannon, Washburn,[2] and Carlson[3] have studied the relationship. It is found that, if the subject is requested to press a key when he experiences the characteristic dull ache or gnawing sensation, the records of his key pressure coincide with contractions in the upper portion of the stomach. Following a meal there are churning, peristaltic waves which spread over the lower portion of the stomach but there are no hunger pangs accompanying these. After about three or four hours (and when the stomach has emptied) the waves

[1] Wada, T. An experimental study of hunger in its relation to activity. *Arch. Psychol.*, 1922, 8, No. 57. Pp. 65.

[2] Cannon, W. B., and Washburn, A. L. An explanation of hunger. *Amer. J. Physiol.*, 1912, 29, 441–454.

[3] Carlson, A. J. The relation between the contractions of the empty stomach and the sensation of hunger. *Amer. J. Physiol.*, 1912, 31, 175–192.

grow stronger and spread into the upper portion. The period of contraction may continue for from 15 to 30 min. and will recur at intervals of from half an hour to an hour and a half, growing stronger as the period of deprivation increases and passing from a succession of pulses to a tetanic cramp.

The question arises: Are these stomach contractions the cause of the general increase in activity? The fact that it is possible to arouse general activity in experimental animals by the direct mechanical and electrical stimulation of the alimentary tract suggests that this is the case. Carlson and Luckhardt,[1] using spinal snake and turtle, showed that such stimulation resulted in both tonic and phasic contractions of the skeletal muscles. We might describe the chain of events, then, as follows: The effects of food deprivation, both chemical and mechanical, acting either directly upon the empty stomach wall or indirectly through the blood stream, initiate stomach contractions. These in turn, through afferent endings in the stomach wall, affect the central nervous system and through it alter the tone of the skeletal muscles and induce contractions. The heightened irritability of the skeletal musculature increases the effectiveness of external and internal changes and, as a result of both internal and external initiating stimuli, their period of contraction is marked by skeletal activity. Subjectively, the stomach contractions are felt as hunger. That the account here given may be greatly oversimplified is suggested by Powelson's[2] finding that, in his experimental animals with transplanted stomachs, the skeletal responsiveness commonly *led* the stomach contractions. This suggests that both stomach and skeletal musculature may be responding to some more basic condition,[3] even though the Carlson and Luckhardt experiments show that the stomach has the power to affect the rest of the responding mechanism.

The Influence of Temperature.—Studies of variability in energy output under differing temperature conditions also serve to remind

[1] Carlson, A. J., and Luckhardt, A. B. Studies on the visceral sensory nervous system. *Amer. J. Physiol.*, 1921, 54, 261–306.

[2] Powelson, M. H. Gastric transplantation. *Science*, 1925, 62, 247–248.

[3] This underlying condition is, at the moment, conjectural. If there is some fluctuating chemical condition of the blood stream, it has not been isolated. There is the further complicating fact that the eating of indigestible matter temporarily abolishes contractions. Possibly conditioning is involved here. Further studies are needed before we can establish the causal connections in this series of events.

us of the chemical sources of our motive power. For example, Agar[1] showed that the number of reversals in water mites, forced to swim in tubes in which the water medium varied in temperature, varied with the temperature of the medium. Above or below a certain optimum (12.5° was chosen as lying within the normal variations which prove suitable for the organism) reversals increase in proportion to the extent to which the medium departs from the optimum condition.

Another study, by Nicholls,[2] has shown that the activity level of guinea pigs steadily increases as the temperature is lowered from 85° to 87° down to a 65° level. At the higher level they spend more than half the time lying with little or no movement, sometimes for an interval of ten minutes without moving. At the lower levels they are almost continuously active. These variations remind one of the commonly reported differences between human activity levels in the tropical and temperature zones and, although the variations experimentally demonstrated are not unexpected, they show that the differences may be quantified and related exactly to the determining conditions.

One experiment may be cited in connection with this latter objective. Using two-day-old mice whose temperature-regulating mechanism had not developed, Stier[3] was able to show that the regularly recurring periods of "spontaneous" activity followed a temporal pattern determined by temperature. Previous studies had shown that in animals without temperature-regulating mechanisms, heart rates, ciliary movements, respiratory movements, growth, and numerous other physiological changes follow an equation of Arrhenius in which the physiological rates are related to the velocity constants of underlying chemical reactions at absolute temperatures. Stier found that the frequency and duration of the period of activity obeyed this equation governing chemical changes and suggests that the facts may be understood if one thinks of activity as beginning as soon as an activity-producing substance reaches a certain supraliminal concentration and ceases as soon as

[1] Agar, W. E. Regulation of behavior in water mites and some other arthropods. *J. comp. Psychol.*, 1927, 7, 39–74.

[2] Nicholls, E. E. A study of the spontaneous activity of the guinea pig. *J. comp. Psychol*, 1922, 2, 303–330.

[3] Stier, T. J. B. "Spontaneous activity" of mice. *J. gen. Psychol.*, 1930, 4, 67–101.

the concentration falls below the threshold. The temporal pattern of activity and quiescence would thus be regulated by the speed of the chemical reactions which form and remove the substance.

When, as in the higher animals, there are temperature receptors, a temperature-regulating mechanism, and the additional complication of the capacity to form habits, this simple relationship is obscured. The temperature-regulating mechanism can neatly compensate for the outer changes, within limits, and our habits serve to anticipate and defeat the outer fluctuations.

The temperature-regulating mechanism, in fact, reverses the order of events which would be found in the chemistry laboratory, for as the temperature of the body surface falls below the physiological zero one sees increased muscular tonus, lowered thresholds, the delivery of glycogen and adrenalin to the blood stream, etc., all symptomatic of an increase in the energy stream. The activation of the adrenal-sympathetic apparatus and the increased skeletal activity tend to raise the body temperature, and as a result this latter hovers about 98.6° F. with remarkable fidelity. At higher temperatures the lassitude, relaxation, shows a slowing down of the combustion process in the skeletal musculature. And as though this physiological mechanism were determined to achieve this equilibrium point with a minimum of energy expenditure to the individual, we see the habit structures of the individual develop into types of social organization: a transportation system hauling trainloads of coal across the continent to meet wintry temperatures, tourists and vacationists migrating to avoid the extremes of winter and summer, and a whole merchandising structure which follows the thermometer. In the temperate zones we note a variability in behavior that declines steadily toward the poles and the tropics, where—if this equilibrium point is to be maintained—the inhabitants must follow such elaborate temperature-maintaining rituals that less time or energy remains for other pursuits.

Physiological "Needs": Optimal vs. Equilibrating Conditions.—There is a suggestion, here, of an optimum condition, a central equilibrium point, around which physiological changes fluctuate, and some have attempted to expand such a description into a general formula governing the fluctuations of energy output. The organism is made up of a set of interrelated compensating mechanisms so adjusted and geared to the supporting environment that every departure from an equilibrium state releases an energy stream which, in the long run, results in a restoration of the equilibrium. Starting

and stopping mechanisms correspond to the states of "need" and "satiety." Respiratory rates respond to oxygen need, intake of food and water compensate for depleted bodily stores, increased activity meets the threat of lowered bodily temperature, the onset of fatigue and sleep raising thresholds and lowering the expenditure of energy checks the processes depleting energy stores. So long as we keep our description on the level of energy changes, and understand that the "needs" which release activity are identifiable physiological states and stimulating mechanisms, our general formula has an experimentally demonstrable basis. Our "optimum" condition, however, is not a state of mental health or social well-being which corresponds to any traditional ideal, but rather to a relatively constant physiological equilibrium. Unless we so specify our definitions, we shall find that our vocabulary of "needs" and "optimum conditions" will trap us into teleological formulations which contain all the animism and nonscientific thinking of an earlier instinct psychology.

Human beings need a variety of things that they are not moved to seek. Chronic malnutrition and the hookworm may combine to produce a state of inanition that requires medical diagnosis and outside motive power to improve. Vitamin deficiency releases no physiological thermostat. And as for such things as a "normal social environment, and other factors which favor physical and mental well-being,"[1] no compensating physiological mechanism will ensure their acquisition. The Lamarckians tried to write an account of evolution in terms of desires which (through use and striving) grew needed body members, and the vitalists in biology have a way of explaining behavior in terms of the function it subserves, letting the end or goal produce the intermediary structures. But neither of these has contributed to the solid structure of scientific fact that constitutes modern biology, and it would seem the part of wisdom for the psychologist to avoid duplicating their errors. The only "needs" which release a stream of energy are those which stimulate us, and unless it can be shown that the traditionally ideal states have a material structure and work upon our receptors—as do the other stimuli of temperature, gravity, chemicals, etc.—we had best leave them out of our generalization.

We might remind ourselves, too, that there are stimulating conditions and physiological states which drive us to anything but ideal

[1] Cf. Young, P. T., discussion of "homeostasis" in his *Motivation of behavior*, p. 81. New York: Wiley, 1936.

ends. The protoplasmic changes induced by morphine addiction induce, after a definite period of withdrawal of the drug, a profound state of shock and a "craving" which is of the very essence of motivation. No good biological end is served by this mechanism, and yet its starting and stopping properties are precisely on a par with the food-taking cycle in potency.

It is also true that there are very definite limits within which these compensating mechanisms function. The capacity of the temperature receptors to adjust to slowly changing conditions without inducing any compensatory adjustments is notorious. The hand that is held in water whose temperature changes very slowly may be seriously burned and tissues destroyed without the subject experiencing any pain, without withdrawal reflexes removing the threatened member. Likewise the stomach contractions and the accompanying hunger pang decline after a few days of fasting, and once this period has been passed the organism may be in serious need of food and yet lack the compensating energy stream. It therefore behooves the student of behavior to seek the limiting conditions, to unearth the stimuli, and to describe the actual operation of these mechanisms, rather than to obscure the facts by a purely functional and purposive description in terms of ideal ends.

Neither is the equilibrium state to be conceived of as a fixed point, but rather as a moving center that is itself altered within the individual's history. Both habitual and maturational factors affect it. There are, on the one hand, the various factors in aging (such as the rise and waning of the reproductive glands) and, on the other, the "nest habits," food preferences, and the thousand habituations which make one man's meat another's poison.

These facts should remind us that when the problem of the energetics of behavior is satisfactorily solved there is still an enormous variability in the expressive and equilibrating patterns which is not accounted for. The physiological description given so far may help to account for the sources of energy and for the surging rhythms and cycles of activity; but these rhythms do not account for the direction which releasing patterns take, and to this latter problem we must turn.

The Emergence of Purpose

"Forced" Reactions.—Two emphases have characterized our discussion up to this point: a denial of the applicability of a purposive-

valuistic description of motivation and the explanation of rhythms of activity in terms of energy-releasing and energy-depleting mechanisms. When caterpillars behave as "slaves to the light"[1] straining toward an illumination source until dead, when morphine addicts display endless ingenuity in obtaining a chemical that operates as a poison, we can see that no principle such as "tissue need" or "optimal conditions" will suffice. The rhythms of activity which are found to be traceable to cycles of endocrine change, or the temperature of the surrounding medium, or to the autonomic disturbances which characterize hunger and the states commonly described as emotional, suggest that we should look for energy-releasing mechanisms *behind* the activity rather than in goals toward which it is directed. The too-complacent individual should, perhaps, bestir himself; but if there is lacking that set of conditions releasing an energy stream, no categorical imperative will budge him. All these considerations help us to account for a certain blindness and lack of adaptation in animal behavior which would otherwise remain incomprehensible.[2]

"Lower" and "Higher" Animals.—The "creature of circumstance" par excellence is the simpler organism, or the young of higher forms in the early stage of their development. And in the simplest organisms this is particularly true, for no amount of "experience" can compensate for their defective structures, and no amount of training can teach them how to defeat the environmental assaults that repeatedly set them in motion (and sometimes lead to their extinction). The amoeba which is fed insoluble and indigestible carmine grains will never learn to avoid them, and the paramecium which, by much backing and turning finally avoids an

[1] Cf. Loeb, J. *Forced movements, tropisms, and animal conduct*, Chap. 5, pp. 47–67, and Chap. 18, pp. 156–163. Philadelphia: Lippincott, 1918.

[2] The other course, which is sometimes taken by the dyed-in-the-wool purposivist, is to seek by devious verbal paths some way of interpreting the phenomena so as to leave purpose in the saddle. Thus McDougall, confronted with the phototropism of the moth which carries it to the flame, and extinction, reminds us that the moth does not fly directly into the flame, "but more commonly hovers round it uncertainly, as though both attracted and repelled, before he blunders into it." And he further reminds us that while such tropic responses may account for parts of an animal's repertoire, "there seems to be no possibility of explaining all the behavior of any animal in terms of this principle." From McDougall, William. *Outline of psychology*, p. 64. New York: Scribner, 1923.

obstacle, never learns to short-circuit the process and to improve his technique of avoidance. The effects of stimulation are temporary, as temporary as the brief physiological changes which they induce. When they have passed, and a physiological equilibrium is once more restored (if conditions permit), the paramecium (or amoeba) must start out with the same "naïve" mechanisms and repeat the same blundering responses.

At precisely this point the higher organisms differ. Stimuli not only release responses, but their effects induce more or less permanent changes. The stimulus which induces energetic withdrawal responses comes to be avoided in advance, and the releasing stimulus which restores equilibrium after a prolonged and blind series of actions comes finally to be sought, early in the series, and skillful and direct releasing activities replace the previous painful groping. Precisely how these changes come about is a problem which we shall discuss more at length when we turn to the learning process, but we can at least formulate their general character here.

Variability, Persistence, and Goal Direction.—That organisms should show persistent and variable activity follows from their very nature, and from the nature of the stimulating situations which they meet. Like a bundle of explosive mechanisms, the "loaded" action systems have but to be tapped and energy is released in the form of activity. Neither the internal nor the external stimuli which play upon the afferent ends of these systems permit any state of equilibrium over a period of time: lights, pressures, odors, etc., come and go, and internal changes (endocrine cycles, respiratory, digestive, and eliminative processes) constantly enforce a readjustment of the effectors. The cycles of activity induced may be brief (as when contraction of a member removes it from the inciting pressure) or of longer duration (as when hunger actuates continuing activity—sometimes over days—until appropriate food stimuli put an end to the disturbing energy stream).

In the inexperienced animal we do not expect such activity to be goal directed. The thirsty chick in the strange barnyard may execute a throat-bill-neck pattern that is characteristic, but we do not expect him to orient directly to the drinking pan nor to discriminate between the reflecting surface of the water and, say, a patch of gray paper. We do not expect the movements of the very small child whose foot is caught between the bars of his play pen to be guided by the visual configuration of the bars. But we do

expect these (and other) inexperienced animals to keep active as long as the sources of stimulation continue to operate.

But though persistent, even the inexperienced animal's behavior varies; and again we need not go beyond physiological principles to explain the fact. A reaction system, fatigued, has higher thresholds, whereas the resting systems grow increasingly irritable as fatigue products are neutralized and depleted chemical stores are replaced. And following one response there is a "relative refractory period" in which it is less excitable. Consequently even a constant stimulating situation will release, not mechanical, repetitive, machinelike activity, but a variable play of responses which have a way of exploring and exhausting the possibilities (of both situation and organism) until the releasing stimulus once more restores equilibrium.[1]

If the beginnings of such trial-and-error cycles are to be called purposive, they clearly represent a very low level of purpose. But in the higher animals at least—in fact, in all animals which show the capacity to learn—the repetition of such cycles brings about an alteration in the activity. The "consummatory response" which restores equilibrium (either through avoidance of the disturbing stimulus or through discovery of equilibrating stimuli) tends to appear earlier in the series, the useless or interfering components tend to drop out. Thus, the hungry rat placed in the experimenter's maze comes to avoid the shock grids, to disregard the blind alleys, to drop his nibbling-sniffing-gnawing-exploratory behavior, and to dash more and more directly to the food box. Stimuli which had equal potency in attracting and directing his responses before, now have sharply differing values as he comes to neglect more and more every item save those which have a bearing upon or provide a support for the releasing movements. His behavior is now highly selective, and it is as though a system of "values" and "meanings" had been assigned to components which hitherto had been more or less equivalent aggregates of energy. Both the character of the response and the reaction-invoking power of the stimuli have changed. On the response side we see the random, self-contradictory, clumsy, and all but aimless groping replaced by a chain of

[1] Even here, reaching a goal is conditional. The inciting stimulus may not be persistent enough, the animal's repertoire may not contain the requisite movement sequences, the particular circumstances may not permit the animal to achieve the releasing conditions before death or exhaustion intervenes.

responses fitting neatly together and all contributing to the consummatory act. On the stimulus side we note that anticipations, associations, have given the isolated elements new powers. The entrance to the alley around whose corner the shock grid is concealed has an inhibitory power, whereas before it seemed to invite exploration. Conversely, the stimuli which clustered about the releasing food stimulus have an approach-invoking power which before they lacked.

As a consequence of this selection process, which occurs as the cycle of tension-release is repeated, the mere presence of the initiating state suffices to release the whole chain. Not only do the hunger contractions alter the whole activity level, lowering thresholds throughout the skeletal musculature; but in the experienced animal they mobilize preparatory responses, "seeking" behavior. The energy stream is canalized, and irritability, restlessness, and random activity are replaced by directed and purposive responses. Motivation changes from mere push to a *push toward*. Lowered thresholds and increased irritability change to anticipations, expectancies, seeking. The experienced animal, like the mother sleeping with ear attuned to the slightest fretful whimper of her sick child, is differentially sensitive. As in the analogy, where the mother may rest undisturbed by the noise of street traffic but waken at the murmur of the child, a "preparatory set" outweighs the physical intensity of the presented stimulus. The meaning of the stimulus may thus be more important than its physical properties.

The Specific Character of Motivating Energies.—Thus, we may describe the emergence of purpose as an at least partial escape from the dominance of the external stimulus. The accumulation of inner controls, preparatory postures and sets, expectancies, introduces a set of values into what would otherwise remain an equivalent group of stimuli. We "pay attention to" some stimuli and disregard others. Our behavior stream acquires a unity and consistency. We go about our business and are less distractible. And as our plans reach into the more and more distant future, and reach out into the social group embracing those around us, we become purposive, planful, willing, and (more or less) intelligent human beings.

As here presented, the description of the emergence of purpose needs qualification. On the one hand, the tensional state tends to appear as a *mere* tension, completely diffuse and random; on the

other hand, the specificity of orientation, expectation, the whole selective side of behavior, is derived wholly from previous experience. This overlooks the fact that energy-releasing stimuli differ in intensity and point of application, that they arise in widely differing receptor surfaces and conditions, and that particular types of stimuli may arouse particular effector groups. It is true that their effects are often widespread. As previously noted, the state of hunger may facilitate dynamometer grip, performance in intelligence tests, salivation, or (as in the child) mouthing reactions; but, although the diffuse character of the innervation which spreads from the alimentary disturbance is apparent, we need not think of it as identical with the streams from other motivating sources. The tonic reflexes released by the gravity mechanism (semicircular canals, etc.) are specific, the stimulus does not spread at random to all the musculature. Similarly, the increased activity and altered thresholds which accompany the ovarian cycle of the white rat show a pronounced effect upon the reproductive structures, and tend rather to inhibit than to facilitate food-taking activities. Suffocation, or air hunger, will have its characteristic as well as its diffuse effects. It seems appropriate to generalize, therefore, and say that *each motivating energy stream will organize its characteristic core of activity, however diffuse its total effect, and coupled with this core of action the various receptor surfaces will display a "threshold profile."*[1]

To illustrate: As we have remarked before, the receptor area about the mouth of the hungry child is particularly sensitive. Every tactual stimulus is an object to be mouthed, sucked, and possibly swallowed. Here the tactual receptors of mouth, lips, and cheeks have low thresholds and require less energy to initiate responses. What our generalization implies is that for every particular motivating energy stream there will be a corresponding lowering of threshold of particular receptors. This is true whether the organism has had "experience" or not, although the obvious effect of experience is to both narrow and complicate the pattern of readiness in both receptors and effectors. There is, therefore, a selective (and to

[1] Cf. MacCurdy, John T., discussion of appetite and interest in his *Common principles in psychology and physiology.* (New York: Macmillan, 1928.) He speaks of a "liminal image of the goal" which may operate on a purely physiological level, as a set of lowered thresholds, or upon a psychological level, as an actual image of the goal object.

that extent *purposive*) aspect to all action, both naïve and experienced, and the motivating conditions will always provide more than a *mere* push.

We might summarize our discussion by saying that organisms are purposive before they are intelligent. Both the organism's history and the energy stream that is impelling it at any given moment introduce selective factors, tendencies, threshold profiles. And within any given individual these purposive and selective factors might be arranged in a hierarchy ranging from the vague and diffuse patterns of readiness which operate in advance of experience and those sharpened and refined, goal-directed skills which represent the residue of experience, knowledge. The whole evolutionary process, as well as the experience of the individual, culminates in the latter form. From the mechanically repetitious and blundering attempts of the amoeba to achieve equilibrium to the efforts of the philosopher to complete a consistent picture of the universe, or of the statesman to carry on the tasks of government, there is a scale of purposes. But the fact that there are all degrees of purpose, that behavior may lead to the release of tensions or to extinction, and that the very emergence of purpose itself has to be explained, should warn us against leaning too heavily upon it as a principle of explanation.

Individuation and Socialization

Motive and Matrix.—Paradoxically, the process which we have outlined results in both the individuation and the socialization of behavior. The purposes which emerge from a succession of tension-release situations bear the imprint of the matrix within which the activity takes place. Adventitious stimuli and particular modes of release become fixated in such a way that these are sought as inevitably as though they were the only fitting and eternally right modes of achieving equilibrium. Although carrier pigeons will not ordinarily mate with ring doves in their natural surroundings, the "laboratory family" in which ring doves are reared with pigeons from the start proves that the "natural" choice can be reversed. In fact, the birds will reject the members of their own kind. If any instinctive "threshold profile" existed it has been overlaid and obscured by habit.

Thus the individual's habits of sleeping and of eating, his preferences for particular foods and for particular methods of seasoning

and preparing them, his tolerance for a variety of sounds and odors, his preference for hills or rolling prairie, the whole galaxy of tastes and preferences that mark him as a unique person will bear the imprint of the particular "maze" or "nest" within which he has learned to achieve releases from tension. The child who has always had his egg soft-boiled will reject the more solid texture of the hard-boiled egg, at least at first. He may refuse to go to sleep without a particular pillow or Teddy bear. The city-bred individual finds countless "disrupting" stimuli in the countryside. And because a death in the family, or moving, or taking up a new occupation means that we have to work out a whole new set of release patterns, we find such situations "upsetting" and exhausting.[1]

Individual and Type.—By the same process, however, "types" are produced. The operation of the common environment will create those resemblances in taste which characterize the family and even larger social groups. The Harvard-type, the middle-class outlook, the "white chauvinism" of the Southerner, anti-Semitism, the proletarian's class consciousness, all bear testimony to the power of the social matrix to stamp a pattern upon the individual. From the beginning, when his helplessness makes him wholly dependent upon others for his very life, the human individual is embedded in a social matrix; and to the end of his days he can secure his ends only through cooperating, in some manner, with those who surround him. Far from a self-sufficient animal at any time, as a child his total dependence imposes upon him the need of paying attention to every cue afforded by those who move about him. Their smiles or frowns and their words or gestures of approval and disapproval speedily become signs of punishment-to-come or permissive "go-ahead" symbols. The family's standards, tolerating some acts and tabooing others, are literally incorporated by the developing child; and the advice, reproof, encouragement, of flesh-and-blood individuals becomes in time conscience, the "unseen witness," or a sense of guilt. When the family, the gang, the schools, the press, the radio, the movies, the occupational group, the church, the lodge have completed the process of socializing the individual, their imprint

[1] Katz suggests that a large factor in homesickness is traceable to the longing for the corn beef and cabbage, the "stack of wheats," or whatever the common dishes of the family and home country may be. Cf. Katz, D. Some problems of human feeding in relation to industrial psychology. *Hum. Factor, London,* 1935, 9, 127–137.

will be carried by him as a set of demands, expectations, purposes. Not only will he seek his kind (they will censor the patterns which he has developed the least) but he will seek to remake his environment (both that of things and that of men) into his own image.

Tensional States the Rule.—Social life thus rears upon the relatively simple organic tensions a superstructure of purposes and expectancies. The process of growth and maturation, which steadily transforms the organic background of action, the process of habit formation and habit breakdown (which in a ceaselessly changing outer environment must be continuous), together with the fact that the hard world of reality never can present at any moment a completely perfect fit to our "threshold profiles" and expectancies, all conspire to make of man an endlessly dissatisfied and restless creature, driven to surpass himself and remold the world. Since only in the highly simplified pages of a psychological treatise do the motivating factors occur singly, the complicated welter of tensions is never completely satiated by any line of action. In fact, the very struggle to achieve equilibrium usually manages to release new tensional streams. Only in the completely routinized life, in the atmosphere of ritual, where life imitates the eternal recurrence which the philosophers speak about, could there be any approach to permanent stability. But alas for all sin[illegible]tions, even the monastery has given us pictures of suc[illegible]e and abnormal types of behavior, such intense and un[illegible]longings (with a rich superstructure of fantasy) that its [illegible]ere seems tainted with the pathological.[1] The fastings an[illegible]llations, the prayers and vigils, are not the behavior of organisms at peace with themselves or the world. The fact remains, therefore, that a bovine complacency need be expected only in animals, with their simpler structures and limited capacity to learn. Only human beings of restricted capacities or those who live in highly simplified and routinized environments will approximate it.

While the basic questions of food and shelter are by no means solved by civilized man, it is to be hoped that they will retreat into the background as motivating factors. Less simple in character, since they involve other persons, the tensions which group themselves around the reproductive function will remain to motivate

[1] Cf. Leuba, J. *The psychology of religious mysticism* (New York: Harcourt, 1925) and James, Wm. *Varieties of religious experience* (New York: Longman, 1902).

man's social life. And beyond these, as well as man's struggle to defeat his natural enemies—pain, disease, and death, there are the tensions which are generated by the very social structure itself. The social organizations which man has built in the very act of satisfying his wants have generated tensions which drive him, willy-nilly, to the building of new forms. The military machine which he builds in defense becomes a threat to his fellows and the market place which was built for the exchange of commodities becomes a noose around the neck of too many producers. All this should remind us that the individual who lives in a society whose fundamental characteristic is conflict and struggle cannot hope to achieve peace within his own breast. There is no salvation for the individual that does not embrace the society which surrounds him.

Biosocial Goals.—But however elaborate the superstructure reared by social life, human purposes can never wholly depart from the lines laid down by biological structure. With increasing clarity the analyses of historian and economist lay bare the fact that clashes between cultures are clashes between economic organizations which are concerned with very prosaic demands, and that political questions are not to be divorced from the economic. And man has found no satisfactory spiritual substitutes for eating, home building, and the rearing of a family. The forms and patterns of release of his simple biological needs will change, they may be endlessly complicated as social life grows more complex. Some few individuals may live out their lives either neglecting or defying some of these needs, and distortions and perversions that are quite unsound, biologically, may persist as a kind of social luxury. But the main lines of social evolution must lie within the biologically imposed limits, that is, if human life is to continue. Even here the statement is conditional, and observation indicates that the limits permit many variations. From one-third to one-fifth of the children in our city schools may be undernourished, and the families of those children, in many cases, will be spending some of their income for the movies, tobacco, chewing gum, radios, and a variety of objects which enable them to "keep up with the Joneses." Young people may postpone marriage and the founding of the family, not because a decent subsistence is impossible on their salary, but because their standards of dress, of amusement, etc., will not fit within their budget. The basic motives may be deflected by those which we might describe as "derived," or as secondary. What we loosely describe as "social

pressure" (combined with high-pressure salesmanship and advertising) may cut into the more adaptive types of action. The "socialized" motive is not necessarily of a higher order, of a more highly adaptive character. The same mechanisms of social approval which produce what we call the "moral" life will motivate the slum-district lad to steal an automobile—if that happens to be the way to achieve status in his gang at the moment.

Human purposes are perhaps best described as biosocial. On the one hand, social forces are involved in the shaping of purposive individuals and, on the other hand, social institutions may be looked upon as means of releasing those tensional states residing in the individual organism. Mutually interpenetrating and achieving but local and momentary equilibria, individual and society contain within themselves the forces producing constant change. If our emphasis upon the blindness and maladaptive character of many of the forms which emerge, together with the helplessness of the solitary individual, seems to smack too much of fatalism and to make all purpose an essentially irrational affair, it is equally true that the only possibility of man's achieving a more congenial existence and of building a world nearer his heart's desire lies in the discovery and regulation of these mechanisms—which otherwise operate so blindly. Whether he will ultimately control the forces to his satisfaction may be an open question, but the steady advance of his control over inanimate nature—through his discoveries in the natural sciences—at least suggests that it will be possible to produce a more satisfactory adjustment between the individual and the group, to produce individuals fit to live together, individuals who will give the term "human" a new meaning.

Attention

A Mentalistic Term.—Although the term has of late fallen somewhat into disuse among psychologists, this purposive and selective aspect of behavior which we have been discussing has traditionally been described as a phenomenon of attention. The attention process, or the faculty of attending, was thought of as opening the sensory channels to some stimuli, while closing others. In the mentalistic and voluntaristic psychologies the mind thus became an active agent, free—at least in a measure—from the imperious dominance of the outer stimulus, and in momentous decisions and in the

resolution of moral conflicts casting its decision in favor of one line of action or the other. Where there were two lines of action, pictured in thought, and leading to different ends, we were told that the attention process accomplished the decision by holding one of the courses in the foreground of consciousness for a longer time, whereupon the one train of ideas became realized in action. Man thus appeared superior to the ass in the sophist's fable, caught midway between the two bales of hay, unable to reach a decision and condemned to starvation in the midst of plenty. In fact, it was largely by virtue of the mind's power to weight the weaker of two impulses—through the agency of the attention—that a moral life became possible. So, at any rate, some were prepared to argue, feeling that if this were not the case man became like any other animal (or automaton), a creature of circumstance, with all his actions forced.

Now that we have become inured to a scientific description of human behavior, and have found that the more exact formulations in objective and physiological terms have added to, rather than impaired, man's freedom, we have much less need for these mentalistic descriptions. And it must be confessed that many of the questions formerly discussed have a strangely scholastic flavor. For example, an unsympathetic reader who covered the experimental studies which attempted to answer the question, "How many things can we attend to at once?" might see an analogy with that other and earlier scholastic question relating to the number of angels which could stand upon the point of a needle. So long as the discussions and debates were within the realm of pure speculation, and so long as the psychologist attempted a purely verbal and introspective attempt to sketch the field of consciousness and block out its dimensions, little was accomplished. Was clearness an attribute of the sensation? Did the center of the field of consciousness differ sharply from the surrounding medium, so that there was a step-wise drop as we passed from the field of attention to the fringe of consciousness, or was there every grade of clearness and awareness? Do the movements of adjusting the sense organ (the fixing of the eye, the "pricking" of the ears, etc.) occur before the attentive awareness or because of the latter? Does attention actually increase the intensity of the sensation, or is the change of a different order—a matter of clearness? What is the nature of the process? Where does it reside?

In our attempts to describe consciousness we have made little progress. So it is with attention, when we approach the problem from the introspective side. If you insist that when you attend your sensations are more intense and not merely clearer, I shall be hard put to it to convince you otherwise; and if you are sure that the field of attention is for you sharply separated from its matrix at the border, I shall have to let it rest at that. The mental contortions involved in trying to have an experience in a normal fashion, and at the same time to scrutinize it critically, like the attempt to study the dark with a flashlight, have not proved very instructive.

Possibly a day may come when some new light on the problem of consciousness will clarify many of the pages of laboratory protocols that have been devoted to the introspective analysis of the attention process; but until that day comes they provide merely a curious collection of psychological literature, scarcely intriguing to those of us who are less patient.

A More Objective Formulation.—The questions which relate to the nature of the process and to its physiological basis, however, touch upon matters of fact concerning which less disputable knowledge is possible. We may ask, too, under just what "conditions" the phenomena of attention arise; and may thus reformulate our problems in more objective terms. The activities of the attending person, the peculiarities in his behavior, are all open to quantitative measurement. It is upon such questions as these that the experimental study of attention has had to center.

Objectively, attention is focalized and directed activity. As a result of this focalization and direction certain stimuli find an easy entrance, others are excluded. Like the sound of a particular instrument singled out from the orchestral background, like the face and form of the expected one singled out of the crowd at the station, the stimuli to which we attend impress us vividly, capture our reaction systems, and later are recalled in detail when the background remains more or less of a confused jumble. While these analogies may suffice for a rough description of the process, we need to ask for a more precise description of the focalization process itself.

Exploratory Movements: Adjustment of Receptors.—That it involves the whole organism can be demonstrated by relatively simple observation. To begin with, there is an adjustment of the sense organs, calculated to furnish the maximum stimulation. The eyes are turned toward the source, the lenses focus, and the eyes

converge; or we may turn the head and cup the ear, as in listening to sounds, and within the ear itself the tensor tympanum renders the drum membrane more responsive. Or we may explore a surface with the hand surface, the light brushing movements and pressures giving us additional cues. Or we "heft" an object, stimulating the fibrils whose endings lie in the striped muscles. And similar adjustments enhance a taste or smell. To attend is, in part, so to adjust the receptors that stimuli may find easy entrance. So strong and so automatic are many of these adjustments that they may operate quite involuntarily, and sometimes on occasions when they contribute little or nothing to the reaction process. Imperfections in the media, or coats, of the eye which are visible under special conditions, as when staring upon a neutral surface or when lying prone and staring into the sky, instantly arouse pursuit reactions in the eye as we concentrate upon them, and since the imperfections rotate with the ball of the eye they are chased, literally, across the field of vision. Or, again, one can see a subject turn his eyes toward the ear to which a faint auditory stimulus is applied, as he concentrates upon it, although this eye movement fails to enhance the stimulus in any way. Whether these automatic adjustments are to be described as a part of the reflex interconnections with which we are natively endowed or as the outcome of many instances where the cooperation of the organs has brought about a release of tension, they operate rapidly and involuntarily. Some of the adjustments are so little within our control, as for example, the accommodation mechanism of the eyes, that, save as they are brought into play indirectly by the act of attending, we have no control over them.

More Pervasive Striped-muscle Patterns.—There are other adjustments that are much more pervasive, spreading into the musculature of the trunk and extremities and often revealing the nature of the stimulus for which we are prepared. Thus Pillsbury writes:

> It has been very clearly demonstrated that every act of the attention is accompanied by a movement which is different enough to mark that particular act of attention off from every other.[1]

Thus, where the parlor "mind-reading" game is attempted in good faith, in addition to the involuntary furtive glances (adjust-

[1] From Pillsbury, W. B. *Attention*, p. 18. New York: Macmillan, 1908. Reprinted by permission of The Macmillan Company, publishers.

ments of the sense organs), the postures of those who have knowledge (as of a hidden object) will often prove revealing, or there will be a hush when the object is approached (cessation of movements and diminution of breathing, etc.), or involuntary exclamations. If one of the group, having knowledge, offers his hand or wrist to the "reader," the latter can sometimes detect slight involuntary contractions which furnish cues as to the location of the object, or the correctness of the reader's guesses, turns, etc. It is upon the basis of such cues that some of the more successful "mind readers" are said to operate, and if one can judge from the reports of the participants, the guide (commonly) and the reader (occasionally) are quite unaware of either giving or receiving cues.

Although the patterns appear less characteristic and do not seem to betray the character and location of the stimulus to quite the same extent, we can see the same spread of the effect of the stimulus as an audience becomes still in the moment of rapt attention. The restless movements, rustling of programs, coughing, whispering, all cease. What we speak of as a "breathless hush" descends. That the breathing is actually altered under the stress of attentive responses is in fact demonstrable in the laboratory, where pneumographic records reveal a more shallow and rapid breathing. It is as though all interfering activities were inhibited; and as though breathing were depressed in order that the noisy passage of air and the massive chest and diaphragm movements might not disturb the fine adjustment demanded for the full and complete registration of the event that holds us "in suspense." The penetration of the stimulus is thus seen to be a two-sided affair, involving the capture of a definite reaction pattern, on the one hand, and the inhibition of irrelevant and conflicting activities, on the other. The mechanisms of facilitation and inhibition which can be seen in the alternate flexion and extension of effectors in the walking reflex in the spinal dog are thus seen to operate at the higher level of our skilled coordinations.

The depth to which the stimulus penetrates may, of course, vary. We walk along automatically, avoiding puddles and preparing for coming turns and obstacles, all the while carrying on an active conversation. The skilled workman carrying on a complicated but routine operation may seem to carry both his work and his conversation in parallel independent lines, that is, in nonconflicting action systems. But the "arresting" thought, the "startling" information, or the question that demands deliberation may interfere. It

apparently demands a larger segment of the reacting mechanisms than is otherwise available. Apparently the stimulus which demands full and complete attention demands the whole organism.

Autonomic Components.—In addition to the arrested breathing, which has been mentioned, there will be circulatory changes: the pulse is speeded, and there are measurable changes in blood pressure produced in part by heart action and in part by contractions in arterial walls. The circulatory changes will vary in their pattern of distribution, depending upon the types of stimulation and the character of the accompanying activities, but numerous studies have shown a general increase in the volume of brain circulation with a corresponding decrease at the periphery. There is also a tendency toward pupillary dilation and a moderate action of the tear glands, the latter giving the "bright eye of interest."[1]

Both the pervasiveness and the prominence of the changes which resound through the effectors prompt one to define the attention process as an "object-centered posture," and to explain the phenomena in terms of the known physiological properties of neuromuscular systems. One is prompted to generalize and to assert that for every act of attention there is a definite and measurable effector pattern, and that an adequate recording technique would reveal that the pattern is characteristic—that is to say, specific and diagnostic. It must be admitted, however, that such a generalization is at the moment to be considered in the light of an hypothesis rather than as a completely demonstrated theory.

The Experimental Study of the Movements of Attending.—As a matter of fact, we have just arrived at the possibility of studying the peripheral changes. Recent developments in electronic physics and the construction of amplifying and recording systems have made possible high-speed records of minimal muscular responses. With such devices it is possible to pick up and register photographically the electrical effects of muscular changes taking place beneath the surface of the body, changes so minute and so rapid that neither introspection nor the closest observation with the eye can reveal their presence. Even with such a technique of recording the problem is by no means simple, for musculature that is apparently resting is found to produce a continuous and complicated record of change; and when one remembers that the attentive posture spreads through-

[1] Pillsbury, W. B. *Fundamentals of psychology*, p. 366. New York: Macmillan, 1934.

out the organism involving hundreds of muscle groups, that it is not a static thing but one which plays and weaves—now about one center and now shifting to an entirely different group of effectors—it is apparent that the problem will have to be tremendously simplified before it falls within the range of anything within reach at present. But it is possible to exaggerate the difficulties. While the best recording techniques are but recently available, other far simpler methods can be made to yield results. A part of the difficulty can be overcome by narrowing the range of the subject's activity, by setting some specific task going and then noting how experimental instructions and relevant stimuli impress themselves upon such actions. An experimental study by Freeman[1] will serve as an illustration.

Freeman placed his subjects in a device resembling "stocks," in which legs and wrists were held in fixed positions. Three-foot levers attached to an optical system, magnifying all displacements 500 times, rested upon the quadriceps of the legs and the flexors of the wrists. A biting board with soft rubber pad on its underside also permitted contraction of the jaw muscles to be included. The optical systems, in which all recording lines terminated, reflected beams of light upon a moving photographic film, thus giving a permanent record of all displacements.

Figure 59*A* shows what happens when there is a shift in the instructions to the subject. At (1) the subject was instructed to be ready to make a discrimination reaction to light by flexing his left or right index finger, but before the stimulus was given he was corrected and told to flex his toe instead. The increase in tension in his forearms following the first stimulus is shown in the lines *R.A.* and *L.A.*, and as the instruction is changed the drop in these lines, indicating partial relaxation, is accompanied by a rise in the quadriceps lines (*R.L.* and *L.L.*).

In another portion of his experiment Freeman was able to show that in addition to setting up anticipatory tensions the character of reflex activities is altered. Thus, the amount of activity induced by an expected shock stimulus was shown to be much less than that which occurs when the subject is unprepared (see Fig. 59*B*).

Other observations of the same experimenter bear upon the question of "effort." In presenting weak stimuli at or near the threshold

[1] Freeman, G. L. The spread of neuro-muscular activity during mental work. *J. gen. Psychol.*, 1931, 5, 479–494.

of sensitivity the experimental task induced a greater amount of tension. The strain of attending, of making difficult discriminations, of reacting to the barely audible and visible, turns out to be a pattern of muscular contractions when treated objectively. Conversely, the task that is found to be "effortless" is done with a mini-

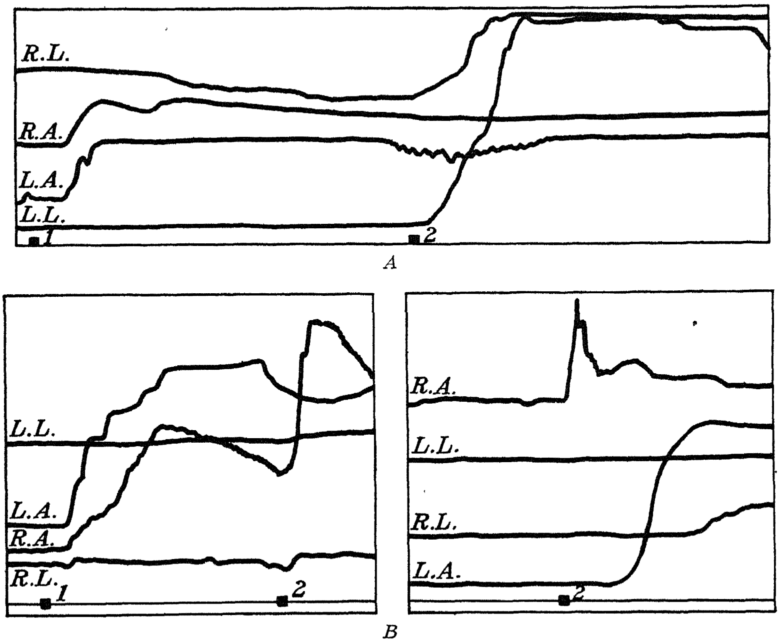


FIG. 59.—*A*. The effect of motor reaction set on tonus patterns. At 1 the subject is told to get set to flex his finger. At 2 the instruction was changed and the subject was told to get ready to flex a toe. *RA*, *LA*, indicate tonus of finger flexors; *RL*, *LL*, indicate tonus of quadriceps muscles.

B. Expected and unexpected shocks. In the record at the left the subject is warned of impending shock at 1, and the shock is delivered at 2; in the record at the right the shock is given at 2 without prior warning. The effect of the preparatory warning is to decrease the effect of the shock (and to increase the amount of tension in the fore-period.) (*From G. L. Freeman. The spread of neuromuscular activity during mental work. J. gen. Psychol.*, 1931, 5, 486, 487. *By permission of the publishers.*)

mum of muscular tension. Thus, Freeman found that during a memorizing task (learning a sequence of nonsense syllables) his measures of tension were found to be correlated with the number of errors. This suggests a narrowing of activity similar to that in the person learning a motor skill, as, for example, a child learning to write. The writhing and tongue twisting portray a whole pattern

of excessive contractions, some of which certainly are not essential to the pattern and many of which are definitely detrimental. As the skill progresses and neatly timed ballistic strokes replace the tense, controlled, halting movements of the beginner, the excessive and antagonistic elements drop out and the action becomes "smooth" and "effortless."

On the other hand, Freeman's experiments cannot be said to have revealed a great deal of specificity in the patterns which he studied. Mental arithmetic, for example, induced (or accompanied, as you will) a variety of tensions, at times mainly in the arms, at other times in the quadriceps. Their continuously variable character, in the words of the experimenter,

> cannot be said to negate the possibility that more specific foci are somewhere existent, [but] they do indicate that the supporting [peripheral] pattern of muscular tension is in almost constant flux.[1]

That these findings do not furnish incontrovertible proof of the motor interpretation of the attention process is evident. They are exploratory rather than definitive, suggestive rather than conclusive. One is inclined to accept them, together with the neuromotor hypothesis, because they fit in with the known character of neural and muscular activity, because they shed light on many of the phenomena of attention, and because their very inadequacy is such as to provoke further experimental study.

The Nature of Preparatory Postures.—In terms of the physics of movement, a posture provides the bearing, the support, from which our movements are thrown. As we stand, prepared to make a stroke with a tennis racket, the groups of antagonistic muscles around every joint must be in balanced contraction providing a stable pillar from which the arm movements may be thrown, and we may set ourselves to receive the impact of our own contracting muscles just as the catcher sets himself against the impact of the pitched ball. Such supports need not be stationary; at times they are slowly moving fixations, as in the weaving posture which supports the trigger arm of the marksman. The tensions which one should seek, therefore, in studying the attention adjustment need not necessarily be minimal duplications of the final complete action. In fact, the more specific (and commonly more peripheral) portion of the action is typically held in abeyance until the appearance

[1] *Ibid.* Reprinted by permission of the publisher.

of the releasing stimulus. But a "preparatory" and supporting posture is assembled. To be attentive, to be prepared so that one cannot be caught off guard, means literally to have the musculature assembled so that the appropriate response can be flung out immediately. Otherwise our response may be slow or fail to appear altogether; it may be inhibited by other patterns antagonistic to it; or, if a response occurs, it will be in the nature of a "startle" reaction, poorly aimed and organized and probably throwing the organism off balance. To choose a figure, the attentive organism is like the player who holds a tightly gripped racket at the appropriate angle for the approaching ball. The inattentive person, on the other hand, like the loosely held racket, may be set spinning by any driving stimulus.

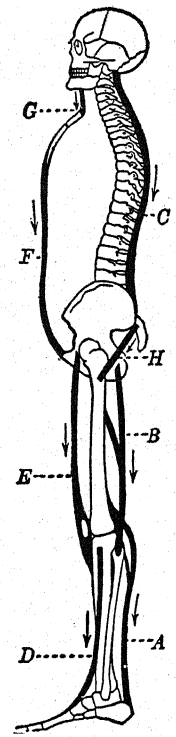


FIG. 60.—Diagram illustrating action of muscles that support erect posture. (*From H. N. Martin. Human physiology, p.* 108. *New York: Holt,* 1912. *By permission of the publishers.*)

All this may be summed up in general terms by noting that it is the organism which attends, and not a brain or a mind. Its selective character reminds us that the organism is never wholly at the sport of external conditions; rather, there is a constant stream of internal conditions providing preparation for one type of action and blocking and interfering with others. Among the internal factors the neuromuscular set looms large.

The Delayed-reaction Experiment.—An illustration of the functional importance of persisting sets or postures is afforded by the delayed-reaction experiment. Originally devised as a test for the presence of ideas in animals, it demonstrates that on occasion an animal's power to retain a postural set defines the limits of its retentive powers. As it was employed by Hunter,[1] animals are first trained to go to a lighted compartment for food. If, as in the plan shown in Fig. 61, the animal is placed in the delay chamber and a light is flashed at compartment 2, in which food has been placed, and allowed to explore until he discovers the food; and if the pro-

[1] Hunter, W. S. The delayed reaction in animals and children. *Behavior Monogr.*, 1912, 2, No. 6. Pp. 86.

cedure is repeated, using each of the compartments a number of times in random order, the animal will soon come to go directly to the food. When the habit has been established, it is possible then to introduce periods of delay, of varying lengths, between the exposure of the light and the release of the animal. (The glass walls of the starting box, which are removable, permit this combination of stimulation and restraint.) Rats, dogs, raccoons, and two-and-one-half-year-old children served as Hunter's subjects. All were able to delay their responses; the rats but 10 seconds, the children for as long as 25 minutes. Hunter found, however, that with both dogs and rats any success greater than chance was always accompanied by a continuing orientation toward the lighted box. Keeping their "attention" or their "mind" upon the task seemed literally a matter of posture. When the neuromuscular set was broken, their responses became no better than chance performances. With raccoons and children intervening movements which displaced such postural fixations did not interfere with accurate choice. In this latter case Hunter was inclined to posit some "central" factor which took over the function of the peripheral neuromuscular system.

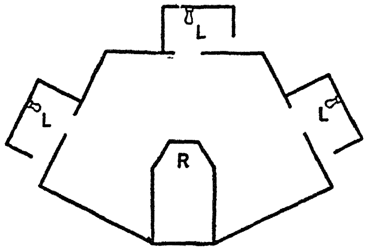


FIG. 61.—Delayed reaction apparatus. *L*, three lights equidistant from *R*, a release box with glass sides that can be simultaneously raised. (*From W. S. Hunter. The delayed reaction in animals and children. Behavior Monogr.*, 1913, 2, 23. *By permission of the publishers.*)

Adult human subjects might be expected to retain the stimulus pattern in terms of some such phrase as "the one on the right" or "the middle one" but in the raccoons and probably in the children such factors would be absent. But in the case of the adult it is clearly not necessary that he keep repeating "the one on the right, the one on the right" without interruption, although we do that very type of thing when the thing to be retained is sufficiently complex, the period of retention sufficiently brief, and the motivation sufficiently intense. In simpler matters, however, we are able to dismiss the whole matter and simply wait for the situation to arise again, whereupon we promptly make the discriminative response. And such discriminative reponses can be delayed over periods which are too long for any physiological reverberation to have persisted.

A year later we remember the very spot where we found the purse, etc., etc. It would seem that the simplest interpretation to put upon these facts is that the presentation of the stimulus has established an organized and patterned response, and that this organization persists until a second presentation of the same stimulus pattern releases the reaction. The experiment thus demonstrates a rapid form of learning (or ease of conditioning), since but one presentation is involved; and it also measures a capacity to retain such momentarily formed patterns. But it has little bearing upon the question of the presence or absence of ideas in animals; and is, again, one of those experiments which may be called suggestive (as supporting the neuromuscular description of attention) but not crucial. This conclusion is reinforced by the findings of other experimenters who are able to show 24-hour delays in the rat,[1] without overt orientation. It does not seem necessary to infer that the rat "keeps the idea in mind" over such a period, and the interpretation suggested seems to cover the case.

Expectancy May Be Studied Objectively.—That the behavior of the higher mammal is intimately tied up with such continuing "sets" and "expectancies" is amusingly illustrated by an experimental study by Tinklepaugh. He used a variation of Hunter's method, permitting a monkey to see him place food under one of two containers, and then after an interval releasing the monkey. Such a problem is not a difficult one for the monkey, and correct choices were obtained under conditions which prevented continuing orientation and for periods as long as 15 to 20 hours. In one variation of the procedure the experimenter, working behind a screen and out of the animal's range of vision, substituted lettuce for the customary banana.

After a delay, the monkey is told to "come get the food." She jumps down from the chair, rushes to the proper container and picks it up. She extends her hand to seize the food. But her hand drops to the floor without touching it. She looks at the lettuce but (unless very hungry) does not touch it. She looks under and around her. She picks the cup up and examines it thoroughly inside and out. She has on occasion turned toward observers present in the room and shrieked at them in apparent anger. After several seconds spent searching, she gives a glance toward

[1] Maier, N. R. F. Delayed reaction and memory in rats. *J. genet. Psychol.*, 1929, 36, 538–550.

the other cup, which she has been taught not to look into, and then walks off to a nearby window. The lettuce is left untouched on the floor.[1]

The Postural Substrate as a Determiner of Conduct.—Thus, although the mere fact of delay is scarcely evidence of "ideas" in animals, such persistent search and refusal to accept all substitutes clearly points to the existence of at least their functional equivalent. Whether we call it "set" or "posture," or appeal to hypothetical foci of activity in the cortex, the internal determinant is there and operates through an ever-changing behavior stream. We find, for example, in shifting from one task to another, that we must overcome a certain inertia in the preceding set, and that there is a "warming-up" period during the early part of which we operate at low efficiency. In manual tasks this will seem a matter of limbering up the musculature and of mobilizing the body's stores of energies. In the tasks which less obviously involve the musculature, whether they be the tasks of the student, the accountant, or the business executive, we may conceive of this period as one in which the habit equipment relevant to the task is mobilized. A whole new neuromuscular set must be brought into action, and while this is taking place the fragments of the older pattern which still persist will slow up the new functions, delaying or inhibiting the new reactions or throwing into the foreground irrelevant items. And when the vivid impressions of a play, fragments of tune from a musical comedy, ghastly details of an accident, obtrude themselves into the subsequent stream of thought, with no obvious associated stimuli in the environment to evoke them, we may think of the interfering patterns as thrown up from the postural substrate. A posture, like a reflex circuit in the spinal animal, is a self-maintaining affair, and the continuing pattern of proprioceptive stimulation throws up the interfering and distracting responses. We need not, as the Freudians sometimes do, appeal to the activity of an unconscious mind; nor will such an appeal add much to our knowledge of the process unless we succeed in physiologizing it.

One can see this postural guide to our activity operating in everyday situations. The housewife turns to the cupboard to reach for a certain spice container and, distracted by a train of thought or conversation, finds that she has forgotten for an instant just what she

[1] From Tinklepaugh, O. L. An experimental study of representative factors in monkeys. *J. comp. Psychol.*, 1928. 8, 197–236. Reprinted by permission of Williams and Wilkins Company, publishers.

is reaching for; but the habitual reaction has unwound so that her hand remains pointed and poised at the appropriate position in front of the shelf. Then she may either hit upon the releasing stimulus among the items on the shelf, or may turn back to the situation which started the train of activities, or—and this is the case in point—the postural train itself may "throw up" the completing item. Or, again, engrossed in conversation with the clerk from whom we have just made a purchase, we may leave the store without the package which we have carried for the past hour. But at the door of the store we discover that "something feels wrong," the posture to which we have returned demands some completing item, and we hesitate until our "memory" provides the missing detail. Of such loosely organized and incomplete patterns our hunches, intuitions, vague sense of something impending, must be composed. Our judgments are thus seen to be much wider than our powers of formulation. Both the continuity of a stream of thought and the organization of a personality are provided for by the whole network of neuromuscular adjustments, more or less stable and continuing postures, which provide the background for more specific high-speed patterns. Like the separate notes and measures that are carried on the longer sweep of the musical phrase, our separate acts ride upon the ground swell of much slower postural changes. Like a web of rubber bands adjusted to a pattern of tensions, the muscular equipment is organized into postures which provide a surface against which the stimulus must strike and rebound. Instead of thinking of our response equipment as a more or less inert piano keyboard upon which stimuli, either singly or in patterns, must work out their mechanical and invariable effects, we are forced to envisage a mechanism with an infinitely greater amount of "inner" determination.

The Interrupted Task.—One interesting set of observations reminds us that a "set" is not merely a mechanically rigid system, but typically a "set for" something. Tensions are oriented toward a particular releasing stimulus. This should lead us to expect a more than ordinary persistence in the unreleased, the unfinished, the incomplete type of response. Lewin and others[1] have been able

[1] Cf. Zeigarnik, B. Das Behalten erledigter und unerledigter Handlungen. *Psychol. Forsch.*, 1927, 9, 1–85.

See also Brown, J. F. The methods of Kurt Lewin in the psychology of action and affection. *Psychol. Rev.*, 1929, 36, 200–221.

to show this experimentally. Of two sets of tasks, one interrupted and the other uninterrupted, there is a tendency to reinstate and complete the interrupted activity. Even where subjects are denied this opportunity, indirect evidence is obtained from later recall, the incompleted activities sometimes yielding scores 90 per cent higher than the completed ones. Observers report that the tendency to complete the responses may be noted even where there is no experimental instruction to that effect, and on occasion the perseverative tendency has been observed and recorded in the form of "frozen" postures and continuing neuromuscular patterns.[1]

Postures and Judgment.—The perseverance of a posture, a prepared muscular set, is shown also in experiments of judgment. When a weight is estimated in comparison with a standard, the initial posture induced by the "hefting" of the standard provides the background against which comparison is made. "Heavier" means that the prepared posture is not sufficient to support the new weight. This is neatly demonstrated by the size-weight illusion wherein the large light object is compared with the small object with high specific gravity. The pound of lead may appear to be five times as heavy as the pound of feathers. When we present the two objects to a blindfolded subject so that no preparatory adjustments can be induced (*e.g.*, by suspending them from cords and eliminating the tactual as well as the visual cue) the illusion disappears. There will remain, however, a "constant error" of judgment which is traceable to the order of presentation.[2] All this further illustrates the operation of persisting postures. They provide the matrix or background upon which the new neuromuscular adjustment is projected.

Such persisting postures may yield an increased efficiency and accuracy of response, or they may distort our responses, introducing the phenomena commonly described as illusions, hallucinations, suggestibility. "Controlled associations" are found to be much

[1] Freeman, G. L. Changes in tonus during completed and interrupted mental work. *J. gen. Psychol.*, 1930, 4, 309–334.

[2] Consider the instance in which the same weight is presented successively to each hand of the blindfolded subject. If one arm has repeatedly lifted a very light weight and the other a much heavier one, it will be difficult to convince the subject that the comparison stimuli are identical. Recently an attempt has been made to link these errors of judgment to the phenomenon of *after discharge.* Sapirstein, M. R., Herman, R. C., and Wechsler, I. S. Mechanism of after-contraction. *Arch. Neurol. Psychiat.*, 1938, 40, 300–312.

more rapid than "free associations." In the former a subject may be instructed to respond with "opposites." Thus, to the stimulus word "black" he will be expected to respond with "white," or to "high" with "low," etc. While our first thought might lead us to expect that this narrowing of the range of possibilities might hamper the reaction, the reverse is found to be the case. It is as though the instruction partially set up the response, and that in addition to inhibiting one set of habits it facilitates and partially prepares another group. There are many facts in common experience which illustrate the same point. A student may find that when he first sits down to write a theme he has scarcely an idea, but that as he starts upon the task ideas begin to crowd around. The very activity summons the relevant memories. Waiting for the spirit to move one is thus a poor method of creative work.

The selective power of preparatory sets is also demonstrated in the simple reaction-time experiment. Attending to the stimulus and attending to the response are apparently two different things. In the former the subject may be instructed to "watch the light"; in the latter, to keep his attention on the reaction itself and to react as quickly as possible. Investigators have reported that the latter yields the shorter interval between stimulus and response. Where the stimulus field is complicated it can be shown that centering the attention upon one stimulus rather than another will facilitate the entrance of the expected one. Where sound and touch are used, a time difference of the order of 50 millisec. is introduced.[1] The classical complication experiment of Wundt, growing out of the discussion of errors made in astronomical measurement, sometimes showed variations up to a second, although it is now believed that eye movements introduce an additional source of error. In Wundt's experiment a swinging pendulum passed across a scale and in its course released a spring which gave an audible click. The subject's task was to locate the incidence of the click, but the results differed by several degrees according to whether the subject centered his attention upon the click or upon the moving pendulum. The original episode which led to the discussion and experimentation is recorded in the history of the Greenwich Observatory and involves the dismissal of the assistant to the astronomer, Maskelyne, whose observations (in calibrating the clock) were as much as eight-tenths

[1] Stone, S. Prior entry in the auditory-tactual complication. *Amer. J. Psychol.*, 1926, 37, 284–287.

of a second off according to his chief. Other astronomers finally became interested in this question of the "personal equation," and succeeding discussion led to its final elimination by wholly mechanical methods. The dismissal took place in 1796, but it was not until 1858 that there was a clear indication that the error was to be traced to an "expectation" factor.[1]

Fluctuations of Attention: Distraction.—Variability is as significant an aspect of behavior as persistence, and attention is notoriously distractible. When we attempt to hold our attention upon very weak stimuli near the sensory threshold we find that they come and go; and with very simple and artificial configurations well above the threshold we may find that a second is the upper limit of duration of response. Similarly, ambiguous fields (shown in Fig. 61A) will be found to alternate under our gaze, whether we attend to them or not. In fact, they will change in spite of our intention to hold them fixed. However fixed our supporting posture, there is still a range within which our responses show a kaleidoscopic play. Elements in the stimulus field at first excluded break in upon the pattern, and irrelevant items from previous sets (perseverating postures) may come and go. In fact, it is only to that stimulus object which presents a rich and complex set of aspects, parts, meanings, that we are able to maintain continuous adjustment for any appreciable period of time. The separate items in the series seem to be self-limited. When we hold a stereoscope to the eyes and view an exposure card arranged so that red stimulates one eye and green the other, we see a succession of green and red, and it is possible that sensory fatigue has something to do with the rate of shifting. But that this concept will not cover all such cases is easily shown when, as in allowing the eye to rove over the staircase figure, stimulating a succession of retinal points and thus lessening any such retinal factor, the reversal continues to take place. In fact, it is frequently in just such shifts of the position that a reversal occurs.

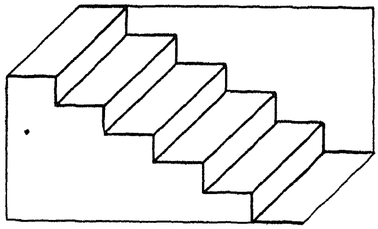


FIG. 61A.—Ambiguous staircase figure.

[1] For an interesting discussion of this problem see Boring, E. G. *History of experimental psychology*, pp. 133–149. New York: Century, 1929.

The fact is that even a "persistent posture" is a constantly shifting and dynamic thing. Holding an arm in a fixed position is not, in fact, equivalent to a steady pull by specific muscular elements. Single muscle fibers explode and relax; it is the larger bundle of thousands of fibers which exert the steady pull, and within the musculature of the arm large bundles will be seen to go on and off, alternately resting and contracting, as the posture remains (only roughly) constant. A record of the movement of holding the hand still (as in keeping a stylus centered over a point) shows, in the tremor tracing, how the antagonistic groups are beating against one another. These facts may serve to remind us of the probable source of shifts in attention. The very nature of postural responses, the inevitability of the fatigue of elements, their constantly shifting and dynamic character, make any persistence at all the serious problem, rather than the fact of shifting. But, although we may feel confident as to the general location of the problem, there is still much to be done before the details of the process are clear.

One interesting, and at first surprising, effect of distracting stimuli has appeared in experimental studies. Instead of decreasing the efficiency of attention (as measured in work output), they appear to increase it, at least after an initial period in which some decline is shown. Accompanying such increased efficiency is a measurable increase in muscular tension, in metabolism, and in subsequent fatigue. Curiously enough, there is a marked habituation factor, and quiet surroundings can prove as effective a distraction as noise, provided the subject is habituated to work under a certain noise level. Apparently the postures of the worker are adjusted and habituated to carry a specific supporting stream of impulses. Departure from the customary conditions initiates a compensatory set of tensions which, in measurable output, increase the efficiency of the process. Obviously, there are limitations to such a distraction effect, not only in the fatigue induced, but in fundamental shifts in the postures which extreme distraction will induce. Extreme distraction will partially disrupt the coordination, throwing antagonistic musculature into gear, interfering with the excursion of members, and the timing of responses. In a similar manner a mild degree of emotional excitement, with its attendant mobilization of energy reserves and "toning up" of the musculature, will improve performance. We are said to be "on our mettle." But more

severe stresses disrupt our skills; at extremes there may be complete confusion or blocking. We hesitate, stammer, flush, etc. And the after-period following the emotional stress is notoriously one of fatigue. In the "letdown" following extreme exhilaration or panic we can feel the actual relaxation of the muscular tensions. We can see that generalizations as to distraction effects unsupported by quantitative studies of particular conditions are of little value.

The Span of Attention.—Our neuromuscular interpretation of attending (as consisting of directed postures, orientations, sets) would seem to indicate that we can attend to but one thing at a time, since we can *do* but one thing at a time. Since we could not possibly adjust the sensorimotor equipment so as to give precedence to a visual stimulus located at one position and at the same instant do the same for another stimulus located elsewhere, it would seem that the problem could be disposed of logically. It is not quite so simple, however, as the experimental facts indicate. If, for example, pied letters are exposed to a subject for an interval that is too small to permit any postural shift (say under a tenth of a second), he is able to report between four and eight of the units. We may call this his *attention span*. If, instead of four letters, we expose four familiar four letter words, his span jumps at once to sixteen. We should remember, too, that a single letter is a complex affair, and made up of many parts. In fact, we need a clear-cut definition of the unit.

Our previous discussion prompts the generalization that the unit is defined in terms of the unifying response. Where experience has provided us with the appropriate integrating sensorimotor patterns, stimuli which would otherwise provide heterogeneous and unrelated items become fused into one pattern. Our skilled coordinations introduce organizations in the stimulus field. This would account for the apparent reduction in the rate and confusion of stimuli as our receiving coordinations are developed. The clicking of the telegraph key seems to slow down as we begin to grasp the larger patterned units. Conversely, the unfamiliar succession of syllable strokes in a foreigner's speech makes his speech seem much more rapid than ours. The phrase, "Ton thé, t'a-t-il ôté ta toux?" when spoken at normal rate by the Frenchman, seems, to the unintiate, much faster than normal English speech. Where the adjustment is made to the larger unit, the succession of adjustments in the hearer *is* slowed.

We have still to account for the fact that four or five of the units are reported from the 100 millisec. exposure. In this case there appears to be a succession of responses to the aftereffect of the stimulus. We react to a reaction. Where visual stimuli are employed, it is possible that continuing retinal aftereffects may provide an afferent stream. There is no reason, however, for confining the aftereffect to the exteroceptors.

A similar problem arises in answering the question, "How many parallel activities can be carried on?" The busy executive telephones, dictates, makes notations of plans, and interviews applicants, apparently running many trains of activity in tandem. It is possible, however, that there is only partial overlapping and that in reality one is witnessing a series of rapidly alternating activities. But a range of activities, from the simple tying of the shoe while carrying on a conversation to the case of automatic handwriting, show that it is possible to carry on simultaneous activities without interference. In the latter case the well-trained subject may take dictation (via the ear) while apparently devoting full attention to reading aloud a passage of abstract material. The dictated passages usually appear unfamiliar when read and one gains the impression of an auditory-motor coordination that is somehow functionally split off from the rest of the reaction equipment. The fact that such apparently independent systems are ordinarily accessible under hypnosis indicates that they are not totally separate. In addition, it is sometimes noted that when the reader strikes a difficult and unfamiliar word the writing hand hesitates. It is as though the unfamiliar and difficult passage demanded more of the musculature, and in the spreading of the effect impulses interfered with the writing pattern.

Experimental studies have shown that the time required for the compound activity, both parts of which are familiar and well automatized, is less than the sum of the separate times. But when either one of the activities is unfamiliar the total is *greater* than the sum of the parts. Even the familiar action is disrupted by the spread of excitation from the unfamiliar patterns.

The Concept of a "Coconscious" Mind.—It was in conjunction with such phenomena that Morton Prince developed his conception of the "coconscious" mind. So intelligent and purposive are these activities which go on outside the fringe of awareness that it is as though they are directed by some conscious agency. Moreover,

under hypnosis the subject's report seems to indicate that at the time the writing took place there was some kind of awareness of what was written, inaccessible though it was to the experimenter immediately afterward. When, however, physiological psychology abandons the concept of "directing" mind and seeks to describe neuromuscular events, the coconscious appears to be as awkward a concept as the conscious. There is no satisfactory account of the difference between those activities which occur beyond the fringe of awareness and those which lie within it. Apparently in the stable environment where activities come to run smoothly, and automatically, the quality which we call "conscious" tends to fade. The newness and freshness of the stimuli disappear; we are not busy sniffing and sensing each item; the greenness of the grass fades—consciousness is dulled by routine. On the other hand, when our routine activities are blocked we are "pulled up" to a realization of what lies before us, and our investigatory and attentive activities go into play.

There is some tendency to attribute this fading of consciousness to the routing of impulses over subcortical paths. There is slight basis for any such interpretation, especially in view of the fact that extensive cortical injuries have a way of destroying even automatic habits. Additional difficulty is presented by the fact that the decorticate animal does not learn fine discriminations, and the automatic activity may involve extremely delicate ones. The simple fact remains that there is no adequate physiological account of the difference between the two types of action.

The Conditions of Attention.—If we are not to elevate an aspect of behavior into cause, we will do well to summarize what has been said and enumerate the conditions which govern the attentive posture. We may say glibly that we attend *because* we are interested; but our analysis should indicate that interest is simply the attention process in operation. Interest is the thing to be explained. Obviously we wish to avoid making an entity of attention, and letting "it" explain the phenomena.

Following Pillsbury, we may divide the conditions into two groups—objective and subjective. In the former we may indicate the characteristics of the stimulus which "captures" our reaction systems, and in the latter those states of the organism which are regulative.

Objective Determinants.—Among the objective conditions we should consider the intensity of the stimuli, their rates of change, their

extent and duration. The more intense stimulus breaks in and dominates the response by sheer force, displacing and inhibiting other responses. As it preempts the response equipment, other stimuli which might call out antagonistic reactions cannot be reported. Minor injuries received in a fight or during a panic will pass altogether unnoticed. Our reaction equipment has been busy elsewhere. Change is a factor and may work in a direction opposite to the intensity factor. The lull in conversation in the crowded dining room is as likely to get attention as any increase in the noise level. Our attention is drawn to the stopping of the clock, the lowering of the lights, as abruptly as to changes in the opposite direction. A minimal but constant stimulus may not be detectable, even with careful scrutiny, and yet the change induced by its stoppage be heard at once. Not only change, but rate of change is important. A spinal frog bathed in water that is being gradually raised in temperature can be literally cooked before a reflex jump is elicited—provided the change is gradual enough. The nurse who is giving her patient's injured arm a "hot soak" needs to control the temperature of the water with a thermometer, for with gradual changes the temperature may be raised to the point where tissues are destroyed without its becoming intolerable to the patient. Where the afferent stream is constant we apparently develop a balancing posture; but a rapid change in the afferent stream upsets the balance of opposing musculature. We might be compared to the fish, lazily maintaining its position against the stream with flicks of tail and fin. If the current is suddenly stopped, these same flicks will carry him forward. So it is that a rapid *lowering* of the level of intensity of the stimulus (as, *e.g.*, stopping of the clock) can capture our response equipment. Effector tensions which find themselves unsupported by opposed contractions must produce movement. When we are adapted, indifferent, a state of equilibrium exists; *any* change will be disturbing.

Up to a certain point both extensity and duration will favor attention. On a chance basis the stimulus occurring over a wide area should have a greater opportunity of striking the receptor surfaces. Similarly, the stimulus which lasts longer should find, sooner or later, the conditions favorable to entrance. Duration also permits a summation effect so that the stimulus has a cumulative strength. There are limitations, however, to both these factors; for, as our discussion of the factor of change indicates, both extensity and duration may permit adaptation. When, as with colored

glasses, the whole field is covered we may lose all awareness of any coloring and be reminded of it only by the sharp change induced as the glasses are taken off. Where the stimuli are repeated rather than continuous, there is less possibility of adaptation, although if the intervals are quite regular adaptation is possible. It is the rapidly changing, unpredictable stimulus which is most insistent.

The factors of *striking quality* and *definite form* have been named as conditions of the attention process.[1] Where these are not reducible to one of the attributes already discussed it is probable that their attention-getting power lies in the subjective factors which follow.[2]

Subjective Determinants.—The various subjective factors commonly named (the "idea in mind," purpose, general attitude, mood, education, heredity, etc.) are all ways of describing the state of the organism at the moment. Of these factors some are more or less continuously operative. Thus, one's inherited structure, as well as one's language equipment, is a factor continuously present and effective. Other factors, such as the effect of immediately preceding stimuli and of one's purpose at the moment, represent the briefer and more dynamic group of determinants. A habit might be compared to the physical concept of potential energy. These configurated residues of previous activities are always present, but at any given moment may be quite in abeyance. The just-preceding stimulus, however, is still actively reverberating throughout the system. The present purpose is simply the reaction system going at the moment. In a sense to invoke this as a cause is to commit the error of the faculty psychologists, namely, to first name the function and then use it as a cause. If the concept of "interest" involves us in such reification, so does the concept of purpose.

[1] Woodworth, R. S. *Psychology*. rev. ed., p. 368. New York: Holt, 1929.

[2] As an example of a striking quality, Woodworth suggests the saturated colors. Although of lower intensity, it is generally more arresting than the pale color. Their rarity in nature, and the fact that they afford sharp contrast to their background, suggest that we are dealing with the factor of change again. The stepwise alteration of stimulation as the eye moves from pale to saturated surface provides the explanatory factor. The same holds true, in a measure, for definite form; but in all probability the power of the definite form lies in the fact that such forms are connected with definite habitual reactions. The amorphous stimulus, the vague outline, has a low reaction-getting value, for the simple reason that we have developed no responses to it. As a corollary to this, one may note that what *seems* at first to be quite formless takes on definite form as we come to be familiar with it.

Both concepts carry a germ of truth, however, in that the response at each moment forms the background upon which succeeding stimuli must play. Thus, when I set out to collect botanical specimens, the reaction systems which are invoked will predispose me to regard the weeds growing in my back yard in an altogether different light than when they greet me as I sally forth with lawn mower and sickle to do a bit of amateur gardening. My "interests" likewise are either a more or less continuous body of such active systems or their momentarily inactive residues. Human behavior is so full of illustrations of such "subjective" control of behavior that one needs scarcely stress the point.[1] Psychological experimentation is almost plagued with it, for the "instruction stimulus" which the experimenter uses to direct the attention of his subjects and to control and regularize their behavior has a way of producing the phenomena he desires, and his generalizations from the experimentally procured data do not always take this fact into account. Thus, the phenomena are often attributed to the operation of physically described stimuli rather than to the directed attention of the subject.

The subjective factors vary in specificity from the vague mood which forms an all-pervasive (and determinative) background for a wide variety of thoughts and actions to the highly specific and definitely organized search for a particular lost article. In a gay mood a wide variety of pleasantly toned experiences may mark its effectiveness, the particular thoughts which arise resting upon other

[1] In listening for overtones, for example, the novice frequently finds assistance in first sounding a tuning fork of the frequency of the partial to be singled out. Or again, if a stereoscope with exposure card colored half in red and half in green be exposed to the subject, he may see either green or red. Which he sees first can be determined by having him first fixate on a field made up of one of the colors, and sometimes by simply telling him to look for one of the colors, or by assuring him in a positive manner that he will see one of them first. The latter fact indicates that the phenomena of suggestibility are to be understood as special instances of verbally induced reaction systems. Under special conditions these are so effective that totally inadequate external stimuli may induce a complete reaction, as when, for example, the hypnotized subject accepts the sheet of paper with vague ink smear as a picture of some well-known public figure.

Again, the selective power of preparatory sets is shown by our experience with the puzzle picture. Having found the hidden face once, it seems to stand out so that we can scarcely believe that it is not visible to others who are looking at it. In a similar manner the self-conscious person expects others to detect the flaws in his costume, facial contour, etc.

determinants. The inclusive set of habits which constitute the "professional attitude" likewise find variable expression, depending upon the particular cases which call for professional diagnosis. Our action systems might thus be arranged in a hierarchy, the more specific ones permitting less and less play of response around the presented stimulus pattern. So, too, the residues of past training vary in specificity from those which provide a formula for dealing with a specific situation to those which give us our taste, and capacity to judge situations, often without the ability to formulate specific reasons. We acquire, through education, the "taste" of the seasoned operagoer or the "judgment" of the experienced jurist; our judgment is critical and selective, even where the relevant items from the past cannot be recalled.

Training both alters the direction and increases the efficiency of the attention process. The capitalist entrepreneur and the revolutionary writer may both be exposed to the Russian social scene: the one will be impressed with the disappearance of the opportunity for profits and the decline of private enterprise; the other will report on the new spirit of the people, or upon collective artistic endeavors, etc. It is as though they had seen different countries. Similarly, training appears to alter the "threshold" of response. Where the city-bred sportsman travels with the Indian guide, and both are searching for signs of game or for the trail, it is as though the Indian guide has superior vision. Minimal cues and complex configurations are singled out by the one with training (as a face in a familiar puzzle picture), whereas for the other the environment presents mere confusion. It is not that the sensory equipment of the one is finer. The New Yorker will "pick up the trail" from one subway train to another, where the Indian guide is helpless. Hence we may think of the habit equipment as providing the selecting, discriminating equipment which reduces the outer buzzing confusion to order and selects the relevant from the background of the irrelevant. The trained mechanic peering under the hood of the car sees an ordered arrangement, a familiar system. The novice sees merely a confused jumble of "gadgets." A moment later the one could report upon or reconstruct the essential arrangements; the other has little that is definite.

In one sense this cumulative effect of experience leads us all toward old-fogeyism and "set" minds. Our very habits act as selective agents enabling us to discover only such evidence as "fits

in" with our already ossified experience. The more we seek to discover the nature of the world the more we tend to discover what we already know. And in so far as our thinking takes place without the external environment as corrective it will tend mainly to elaborate and fixate our previous convictions.

Social Forces and Attention.—The common interests, tastes, preferences, which characterize social groups suggest that a fruitful analysis of the attention process is possible at an entirely different level. Instead of discussing the physical character of the stimulus and the physiological action of the organic predispositions, one may seek the characteristic forms of selective activity which characterize specific groups.

When Kimball Young[1] writes of class and occupational attitudes, and of the influence of primary and secondary groups, he is providing a concrete description of the outcome of the process which we have tried to discuss as an individual problem. Family, gang, and neighborhood, educational, professional, and occupational groups, and finally racial and national groupings all produce characteristic effects. The social institutions provide the mold into which the plastic human structures are forced, and if the social institutions are themselves in conflict this larger pattern of stress will be reflected within the breast of the individual. Supplying as they do a system of sanctioned and codified ways of life, together with effective powers of criticism, they are the source of our systems of value, our religions, our philosophies. And as their effects become incorporated within us as a system of expectations and preferences, our consciences, artistic and moral, are formed. The thousand and one bits of advice, the corrections of our parents, the gibes of the gang, the ubiquitous advertiser and high-pressure salesman, all become, finally, pressing desires and demands of the individual, and an "unseen host of witnesses."

Before we are aware of their power their effect has been felt, and once felt, leads us to particular environments where cumulative effects compound the original one. Our childish scribble seized upon by fond adults as the sign of dawning talent, and praised, may become such a matter of attention and interest that we busy ourselves with crayon and drawing paper while other children romp at other types of play. Every instance of such choice, providing as it

[1] Young, Kimball. *Social psychology*, Part III, pp. 203–399. New York: Crofts, 1930.

does additional training of discriminating responses and visual-motor coordinations, will render us more susceptible to further stimuli of the same type. If our surroundings provide us with copy, and with a system of praise and reproof which holds our attainment to a higher level, if educational advantages are provided, it is probable that the age of twenty will find us with skills and interests which most of our fellows will judge to be the result of some special "native talent." For do we not have the ability to reproduce in line drawings the things which we see, to a degree that our equally mature fellows cannot aspire? And can we not even see items which others miss? This imaginary history, it seems to me, is the prototype of most developing talent, instead of the one commonly accepted.

The conventional picture is one in which we start with hereditary differences in bodily equipment. Just what these differences are, students of special abilities seldom tell us. But it is urged that, given this inherited capacity, contact and opportunity merely provide the conditions necessary for its development. The individual may fail altogether to discover his forte. But if the conditions are provided he will develop at a more rapid rate than his fellows, achieve social status through his particular gift. The social recognition and reinforcement *follow* upon the primary fact of inherited differences. But in spite of much labor, the endeavor to seek the biological bases of special talent has not been particularly successful. If it should turn out that the sense of rhythm and the sense of pitch are both inherited traits basically (and there is considerable doubt about the extent to which this is true), it would still be a question as to whether the child with these traits present in high degree would be a clog dancer, piano tuner, saxophone player, or concert pianist. The number of people who have a keen sense of pitch and no musical ability, the number of artists who have less than average visual acuity, etc., raise serious questions for many "nativistic" views of special talent.[1] According to the biological view, original capacity consists in some vague and as yet incommensurable congeries of physical traits which not only provide the raw materials for development, but, barring a markedly hostile environment, really

[1] The fact that track coaches have as yet failed to devise any set of measures, any system of selecting those natively gifted in the relatively simple skills with which they deal makes one rather pessimistic for the immediate future of any program directed toward the selection of those natively gifted in the more complicated arts.

predispose toward a particular line of development. According to the view here suggested, it is the social matrix which supplies the shaping factor. It provides both contact and opportunity with the necessary training situations; it provides the system of praise and reproof which act as motivating factors. Beyond supplying the raw materials, the organism is not an effective agent.

It is true that the organism can supply handicaps which will make training more difficult in particular fields. One does not as a rule find blind sculptors or deaf musicians. And if we pursue our logic relentlessly we must admit the existence of factors which *favor* certain lines of development. The boy with the build of a Falstaff does not go out for the hundred-yard dash, but those nearer the Jesse Owens type do. That is, many of them do. However, they may possess the requisite proportions (in so far as these are determinable) and feel no impulsion or interest in that direction. *If* the social factors conspire to give them an interest, and *if* the approval of the immediate witnesses is important to these particular individuals, and *if* within the particular situation their biological equipment displays itself to advantage, then the pursuit of this new line of endeavor may seriously begin. There are too many ifs, however, to make the purely biological explanation a satisfactory one.

As if to confound the student of human nature, the Viennese psychoanalyst, Dr. Alfred Adler, developed a theory according to which our main life line is founded upon a compensation for organic inferiority. Realizing our weaknesses and obsessed by fear of failure, and impelled instinctively to be a complete man or woman, we build defenses with feverish activity exactly at that point where our biological armor is weak. Confronted with the family crisis surrounding the death of his small sister, and captivated by the physician's instruments, his power over life and death, his status in the eyes of the family, the boy may envisage a medical career as the best way to defend himself against the mysterious enemy. Or, handicapped with a speech defect such as stammering, the boy will daydream of his triumphs as an orator or doctor; and he may (like Demosthenes) so struggle in overcoming his handicap that in the end his speech is above the average.

But like so many facile generalizations, this one has but to be stated, and the exceptions begin to occur to one. Pushed to an extreme it becomes a logical absurdity. Universalized as a social policy it would involve us in the attempt to defeat nature in order

to call forth its best, to stunt our trees that they might be driven to grow unusually tall. Nature does provide abundant instances of compensation, and defects, both biological and social, will write their influence upon developing children. But compensations turn out to be indirect, usually, and in many cases they do not occur at all. The outcome of a defect must be studied under the particular conditions in which it develops. The effectiveness of the compensation will depend upon the wisdom and skill of those who direct it, and upon the cooperation of a thousand supporting (and not crushing) circumstances. The compensatory thrust may turn inward into the field of fantasy or may display itself in an embittered and destructive attempt to minimize the accomplishments of others.

Conflict and Will.—Throughout our discussion of motivation the reader may have felt that something is missing, that the intangible factor which we call "will" should somehow be brought into the picture. For we do hold our attention to uninteresting material, voluntarily; we do achieve in spite of obstacles, and effort does count. Are these facts to be overlooked or denied? And what is it that resolves conflict, if it is not the act of will?

Rather than deny them, we have been trying to explain them. The voluntary act of attention we would trace to social factors, for have we not traced the conscience which supplies the "must" to this source? We hold to the remote objective, complete the immediate distasteful task, and work toward ends that are set by the larger group to whose standards of approval and disapproval we have been conditioned. Our "ideals" are not inventions which we have worked out in any solitary manner.

And if we give a name to the resolution of conflict, have we in any sense explained it? Do not the forces which have produced the conflict impel us to decisive action? Peculiarly enough, we have a way of staying on the winning side. We put away the old self and identify ourselves with the new. The very forces which make one reaction system dominant "seal off" the other possibilities and prevent them from rising to plague us. Sometimes when the decision has been forced upon us, this suppression of the vanquished systems is less successful and we become two selves, the outer one which we display to our friends and the inner one which is engaged in living out in fantasy the possibilities which reality has denied. Or where the decision was a doubtful one over which we vacillated for a long time, we turn back wistfully in thought to that parting

of the ways and speculate as to what that other life would have been like.

But as to some reservoir of power, some moral force which triumphs over all the physical, physiological, and social factors which we have named, psychology must profess complete ignorance. The freedom of the will, in this sense, is in fact denied by the very presuppositions upon which the science is built. If some *deus ex machina* were free to descend upon our warring reaction systems and decide the conflict in favor of one or the other, the quest for exact descriptions, laws of human conduct, would be a fruitless one indeed. Only spinal animals would be worth studying, and since the findings would be inapplicable to man and society, the final value of such findings would be very limited. And it seems equally true that the labors of the priest and the psychiatrist would be equally fruitless; in fact, one wonders whether a moral life would be possible. Certainly they could not hope to *determine* the results of their efforts.

A man's freedom in a world where there is much ignorance and where his destiny is at the mercy of forces over which he has no control is a limited affair at best. It is inevitable under such circumstances that our wishes should prompt us to believe in a variety of fanciful philosophies rather than the hard logic of determinism. To the one who is comfortably placed, and endowed with a modicum of knowledge, it is easier to accept both materialism and determinism. He feels that the forces of the world are not altogether bad, and since they respond to his manipulation, not altogether willful and vagrant. In a measure, man has become such a comfortable, half-wise one; and as his control over nature grows and as he achieves a less barbaric social life, the need for such magical powers as are implied in the concept of the "free will" will vanish.

CHAPTER VIII

LEARNING

The Modification of Behavior

Throughout the preceding chapters there have been repeated references to the learning process, to modification of behavior. Many activities which were once described as instinctive and attributed to inherited structure were found to be the product of a learning process and to have been influenced by the stimuli met in the course of the individual's life history. We saw, too, that the emotional responses of the individual, while involving the inherited autonomic mechanisms, could be attached to an endless variety of stimuli; and we saw that there is a great probability that the patterns themselves undergo considerable individuation and modification. So, too, the drives, interests, and motives of the individual bear the imprint of the situations through which the individual has passed; his previous successes and the surrounding matrix of family and larger social group have oriented his strivings. The phenomenon of learning is, in fact, the central psychological problem.

Now, modifiability is a universal phenomenon. The lowly amoeba shows it to a limited degree, and even the members of the plant kingdom "adapt" to their surroundings. There are distinctions to be drawn, however, between these universal and primitive types of modifiability and those which form the core of the psychological problem. When, for example, an *Amoeba proteus* is allowed to roll into the path of a directed beam of ultraviolet light its advance is checked, and if the light is of sufficient intensity, the forward end seems to undergo a type of gelation, the rear portion becomes fluid, and the flow is reversed. In a weaker light the reversal is not immediate, and the animal gives the appearance of sending out feelers in various directions, of trying out various avenues of advance, and only "reluctantly" reversing its course. If the same organism is subjected to repeated trials, the number of pseudopods thrown out declines and reversal comes more and more immediately. On the surface it would appear that the amoeba has "learned its lesson"

by trial-and-error method. But if this be a type of learning, then we must add that the amoeba's memory is very short; for when a sufficient interval of time has elapsed for the chemical change induced by ultraviolet light to disappear, the amoeba has to go through the same stages of learning as before. Nothing of a permanent nature has been established. Its memory is as persistent as a diffuse chemical state, and the changes which are set up by the light stimulus appear to be reversible.

Primitive Variability vs. Learning.—The human being also shows this primitive type of variability. The neurologist who studies the responses of the exposed cortex finds that repeated stimulation of the identical spot (in so far as he can control it) in the motor area will elicit a varied series of responses: at one moment fingers may be flexed; the next stimulus elicits extension. So, too, the varied manipulations of the learner confronted by a problem situation may be due in part to the "fatiguing" of some reactions, rendering other mechanisms more easily elicitable. But the modifications which we commonly think of when we speak of learning are, on the one hand, more permanent than the transitory changes we have been describing and, on the other hand, more flexible (and reversible) and more rapid than the slow, irreversible changes which come with growth. Moreover, the changes in the behavior of the learner show a remarkable adaptation to the specific character of the environmental changes which induce them, in contrast to the diffuse and massive changes which have been described. The pattern of movements shows such a neat adjustment to the external patterns that we are moved to describe the adjustment of the learner as *purposive* in contrast to the "blind and mechanical" changes of a more primitive type. Is there a mechanism for these higher types of change? Can we show that these most purposive adaptations are also *forced* upon the learner?

The Nervous System and Learning

One way of describing learning is to say that it consists in the establishment of new stimulus-response connections. The child that has been "conditioned" to avoid the hot radiator now reacts to the visual stimulus in a new way. Previously it was a contact (and stimulation of nerve endings in the skin) which elicited withdrawal; now the child avoids the *visual* radiator. Since we know that the route to the effectors lies through the nervous system, it is con-

venient to describe the learning, physiologically, as the establishment of new neural connections; and since the nerve paths offer no place at which stimuli can be transferred from one trunk line to another save at the synaptic junctions, and since the cerebral cortex forms a meeting place for fibers from all parts of the body where any incoming path may be joined to any outgoing nerve, it seems probable that essential physiological changes occur at the central junctions.

Habit Formation Appears with the Synaptic Nervous System.—Other facts reinforce this view. It is not until we reach the worms, that is to say, the first forms which possess a synaptic nervous system, that learning—in the sense we have defined it—appears.

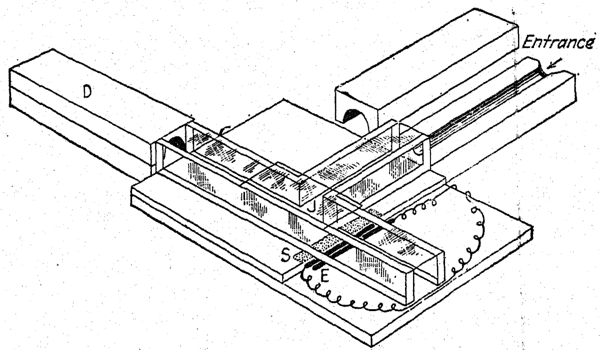


FIG. 62.—T maze for studying learning in the earthworm. *D*, dark chamber; *E*, electrodes; *J*, junction of alleys; *S*, sandpaper. Alley walls are of plate glass, and removable blotting papers cover the floor. (*After R. M. Yerkes. The intelligence of earthworms. J. Anim. Behavior*, 1912, 2, 333. *By permission of the publishers.*)

Although the starfish possesses a nervous system, the fibers are arranged in a continuous net, there is no central meeting place with synaptic junctions, and modifiability is solely of the type displayed by stentor and paramecium (*i.e.*, temporary and reversible alterations). The earthworm, on the other hand, if placed in a T-shaped groove and stimulated by light, will travel down the alleys until it reaches a darkened chamber; and if this chamber lies, say, on the right, the left turns (into the blind alley which may also contain shock grid) will be gradually eliminated until the point is reached (somewhere between 20 and 200 trials) when the worm regularly takes the correct path to the objective. This selection of a "correct" response and the simultaneous elimination of errors, involving as it must the substitution of stimuli and the establishment of new

reaction arcs, is quite impossible for the lower forms which do not possess a synaptic nervous system.

Evolution of the Nervous System and Plasticity of Behavior.—In addition to such observations there is the fact that there is at least a rough correspondence between the degree to which the central ganglia of the nervous system are developed and the organism's plasticity and capacity to modify its behavior. Furthermore, it is in precisely those animal forms which show the lowest order of development of this loop-line system that the process of maturation most completely accounts for the development of the young. The young worm and the young guinea pig have at the very start of their lives an equipment which is sufficient to care for their needs. And, in contrast to the human infant, there is relatively little that the simpler forms *can* learn. The human infant, on the other hand, with an almost infinite capacity for habit formation, is born helpless, and seems to have to acquire its more complex coordinations by a stumbling and blundering learning process. Whereas the young monkey is ready to walk in twelve *days*, the human child commonly does not walk until twelve *months*, and if it is for any reason kept from practicing—by excessive weight, long dresses, etc.—the time is much longer. The length of infancy, the helplessness of the child, the increase in learning capacity, the superior development of the cerebral cortex, the subordinate role of maturation, seem all to be associated.

Inadequacy of Neurological Knowledge.—But if the synaptic nervous system and the higher centers form an integral and essential part of the learning mechanism, our earlier studies of the nervous system have shown that there is comparatively little beyond this general statement that can be made at the present time. We know nothing of the intimate changes involved; in fact, there is much evidence to controvert the older notion that learning consists in sharply localized changes which link cell to cell, and there is evidence now on hand which shows that learning (in the dog, for example) can take place in the absence of the entire cerebral cortex. Although the earthworm will lose its right-turning maze habit when the head ganglion is removed, it can relearn the habit after the operation, and at the normal rate. All the evidence supporting the concepts of mass action and vicarious functioning has disabused us of our simple notions of cortical mechanics, and in doing so has left us practically without a neurological theory of the learning process.

We shall have to formulate our description of the learning process, therefore, in terms of the total behavior of the learner; and it is much better that we do so, for whatever happens in the neural structures can be but a fraction of the totality of changes. Impulses may be conducted through and by means of the nervous channels, but it is the organism that learns.

Early Descriptions of the Learning Process

In the days when men were content with psychological descriptions carried on in terms of the rational soul (which distinguished men from brutes) the task of accounting for human learning was comparatively simple. Learning was a function of the soul, of its faculties (reasoning and intelligence), and that was the end of it. Even the most daring materialists and mechanists, such as La Mettrie, who could venture to write of *Man, the Machine,* never quite got rid of a peculiar "mental element" as an explanation for intelligent adaptation. To modern ears these mental constructs, these faculties, sound like makeshift devices to cover up ignorance; and in truth they explain nothing. To refer the phenomena which we see to an unseen mental faculty does not extend understanding or advance prediction and control; and there is, moreover, in all such explanations a tendency to neglect the actual phenomena.

From the standpoint of comparative psychology, which concerns itself with the adaptations of animals as well as with those of man, an additional difficulty was encountered. Were the brutes to be endowed with a soul? Or with some blind force or impulse, such as instinct, which provided them with a kind of natural wisdom? Or were the motions purely mechanical so that, as one philosopher averred, they go where their legs carry them? The problem was brought sharply into focus with the advent of Darwinism, and it was generally agreed that whatever principles sufficed for the animals must suffice for man, and that no sharp barrier (such as the presence or absence of a soul) could be imposed between man and beast; the higher faculties claimed for man would have to have their evolutionary precursors in our animal ancestors.

The first full impact of this evolutionary notion resulted in a humanizing of the animals. The neo-Darwinian writers seemed anxious to close the gap between man and his lower blood brothers, and did so by imputing to the latter most of man's faculties. It strikes one that Darwin's followers seemed to be saying to their

contemporaries, reluctant to admit this kinship, that the brutes are not, after all, mere brutes. They found instances of communication, social life, division of labor, maternal love, intelligence and reasoning power; and the beehive, ant colony, and animal herd were seen as primitive social organizations. The first compends of information relative to animal conduct were replete with examples of this anthropomorphic tendency.

This anthropomorphism of the overzealous neo-Darwinian colored his account of the learning process. Collecting his materials from anecdotes, letters to the London *Times*, and his own chance observations—for the most part—he was inclined to think that his task had been discharged when he had put himself in the place of the animal (imaginatively!) and had given an account of the mental processes, associations, reasoning, which took place. Thus, when Romanes observed a cat open a stable door by holding to the metal loop below a thumb latch with one forepaw, pressing the latch with the other, and pushing against the door posts with her hind legs, he concluded that the cat

> . . . must have observed that the door is opened by the hand grasping the handle and moving the latch. Next she must reason, by the "logic of feelings"—If a hand can do it, why not a paw?[1]

The Trial-and-error View of Learning

Thorndike's General View of the Process.—When the descriptions of the learning process were of the anecdotal variety illustrated above, the explanations of the behavior in terms of implied and inferred conscious states invented by the observers, not much could be hoped for in the way of a scientific analysis and description of the learning process. In America a young graduate student—somewhat out of patience with these textbook fables—decided to bring animals into the sacred precincts of the university laboratory and to observe accurately just what took place. Building various types of mazes out of books and puzzle boxes out of old packing crates, he proceeded to study how a confined animal learned to escape or how a hungry animal learned to get to food. There were strings to pull, platforms to mount, alleys to travel down; and dogs, monkeys, cats, and chickens were studied as the problems were solved. At the conclusion of his observations Thorndike wrote:

[1] Romanes, G. J. *Animal intelligence*, p. 422. London: Kegan Paul, 1882.

So far I have only given facts which are quite uninfluenced by any possible incompetence or prejudice of the observer. These alone seem to disprove the existence of any rational faculty in the subjects experimented on. I may add that my observations of all the conduct of these animals during the months spent with them, failed to find any act that even seemed due to reasoning. I should claim that this quarrel ought now to be dropped for good and all, that the investigation ought to be directed along more sensible and profitable lines. I should claim that the psychologist who studies dogs and cats in order to defend this "reason" theory is on a level with a zoologist who should study fishes with a view to supporting the thesis that they possessed clawed digits.[1]

From this time forward psychologists industriously collected observations on the learning of all animals, including man. What Thorndike had done for his dogs, cats, chicks, and monkeys was repeated upon raccoons, earthworms, snails, turtles, sheep, children, etc., etc. And the stories showed a remarkable consistency. In sum, it amounted to this: animals do not learn new adjustments by a process of reasoning. They do not imitate one another. They learn by blundering, by trial and error, or by trial and success. They learn by doing. The new situation can call out only those coordinations which are already established. If it is a very young animal, the simple reflexes will be evoked; if an experienced animal, all the additional habits may be aroused. Unless the situations are arranged so that, by chance, the correct response appears as one among this random group evoked, the adjustment cannot be achieved. Driven by impulses, blind at first, the animal stumbles and blunders in random fashion until he finds a way out.

Thus a hungry cat placed in one of the puzzle boxes outside of which a bit of fish is placed in full vision will show "evident signs of discomfort," will bite, claw, thrust paws between the bars, striking at anything loose and shaky, will try to squeeze between the bars; and this will continue until by chance the appropriate loop or button is struck and the door opens. The responses seem blind rather than deliberate; the solution quite accidental rather than planned. On repetition, much the same thing occurs except that the time falls, some of the errors get eliminated, and the correct response occurs earlier and earlier in the series until, on being placed

[1] Thorndike, E. L. Animal intelligence. *Psychol. Rev. Monogr.*, 1898, 2, No. 4, 1–109. Reprinted by permission of the publishers.

in the box, the cat moves directly to the loop or button, and release is immediate.

For purposes of description and analysis we may divide such trial-and-error learning into the following stages:

1. Drive
2. Block
3. Random movements
4. Chance success
5. Selection
6. Fixation

Drive. *Drive as Persistent Stimulation.*—Comfortable, complacent animals do not learn. New adjustments are forced when the animal is placed under a tension for which its habit equipment is inadequate. Where, on the other hand, there is no tension, or where the routine of habit suffices to bring about immediate release, the behavior equipment receives no new additions, undergoes no modifications. When the maze or puzzle box is made quite comfortable for the animal, the latter may react as though the maze were a new home, casually exploring it for a while and then lying down to sleep. Described objectively, then, *drive* will be any persistent stimulating condition in the environment, any muscular or glandular state, any organic condition of excitement and tension, for which the present habit equipment can furnish no immediate release.

The Autonomic System as a Source of Stimuli.—Current discussions of motivation place varying emphasis upon four different factors: autonomic processes and tissue needs, the external stimulus, postural tensions, and the action of the nerve centers. Those who stress the importance of the autonomic factors point out the vital importance of these life-maintaining processes. Not only are they present and functioning before the striped-muscle integrations, but they are peculiarly insistent sources of stimulation. The smooth muscles are slow to fatigue, and the chemical products of the endocrine structures provide enduring sources of stimulation. These internal sources of stimulation are less easily avoided than the external sources, for in the case of the latter the receptors have but to be turned away and stimulation ceases. The random character of the beginner's responses would thus be an expression of the fact that the autonomic impulsions are but poorly integrated with (and in command of) the striped musculature, and the process of habit

formation would be viewed as one in which these diffuse autonomic streams become connected with particular releasing activities. Under this view the autonomic system is conceived as utilizing the rest of the response equipment (receptor, neural, and muscular) in the achievement of its ends. Thus, the hungry animal is moved about under the visceral impulsion until its receptors come in contact with the stimuli (food) which release the original tension.

Preparatory Postures in the Striped Muscles.—But such a view would hold for only the very beginning. Once habits of release have been established, the autonomic seems to drop into the background and serve as a general reinforcer or inhibitor. The workman, who in the midst of his task suddenly finds a need for a particular type of drill, turns to his workbox, searches through his kit of tools, guided all the while by preparatory tensions of the striped musculature; only when under insistent pressure and with failure to achieve his objective does the reaction involve strong autonomic components. The guiding striped-muscle tensions are even visible when, for example, we are caught on a camping trip without a hammer, and as we walk about looking for a stone, a stick, a "something-to-pound-with," our very posture and gestures reveal the nature of the "objectives." It is precisely in the experienced organism that we should expect such striped-muscle "objectives" to play an important role; previous releases have left their residues, and the organism that is experienced does not experience a mere tension, but rather assumes an orientation toward a stimulus-to-come. The contrast between the autonomic-tissue-need description of motivation and the one which emphasizes oriented postures (stressing the striped rather than the smooth muscle components of response) is thus not an irreconcilable one; it is, rather, the contrast between the beginner and the more experienced performer. The hungry infant can do little but squirm, thrash his arms and legs, and cry; the older youngster can hie himself to the cooky jar. The learning behavior of these two levels is consequently quite different; the former is almost completely random, the latter is directed toward rather specific objectives. And in the latter case the movements which are released show the control of the directing postures; they are not random, but look like means-to-end reactions.

The External Stimulus.—The third component, the external stimulus, is always present. On the one hand, it is always present as the environmental substrate, or support, upon which the behavior

is executed. Muscular contractions do not take place *in vacuo* but always within (and against) an impinging and regulating stimulus field. And, on the other hand, external stimuli provoke action, disturb equilibrium, and initiate the very tensions (autonomic and postural) which we have been considering. The block that interrupts the smooth flow of habit is external, and the field of "objects" through which the learner has to thread his way provides an external regulation. If we push this view to its extreme we shall in the end view all behavior as "forced." This was the conclusion of Jacques Loeb, who saw no reason why the account of the swoop of the bird of prey should not be described in purely physical terms, precisely as we would describe the motion of any other falling physical body. So he described the phototrophic caterpillar as a "slave to the light," and with his chemotropism, rheotropism, galvanotropism, etc., was ready to calculate the path taken by an animal in a field of stimuli as the resultant of the combined action of external forces. If this emphasis is properly modified by the two which have gone before, it will provide a reasonable approach to the problem of motivation. But we need to remember that for any organism which can learn (and which has learned anything in the past) the physical stimulus is no mere physical stimulus. It has "powers" and "demand characters" which are derived from the situations in which it has figured before. The animal's past is compounded with the present. It is likewise necessary to take into account those internal cycles and rhythms which the organism possesses. By virtue of its very structure and internal chemistry the organism is a selective agent, determining which of the impinging physical forces shall be effective.

Can We Place "Controlling" Drives within the Nerve Centers?—Lastly, what of the nervous system and motivation? What of ideas, images, thoughts? What of the cells of the cerebral cortex, particularly of the frontal lobe (where an older psychology was inclined to place "will power")? There are many who still prefer to locate the root of the motivational problem at just this point. These writers would describe the posture of the runner, crouched on the mark, as though it were kept tense by the continuing action of nerve centers. In their description the stimulus which arouses an impulse toward persistent striving is pictured as setting a group of cortical cells into activity, and the implication seems to be that—once aroused—these cells continue to be active, and without additional support from an inciting sensory stream keep discharging

into the musculature until the objective is reached. Shall we, then, add to the three sources of motivation a fourth, and speak of the stream of energy discharging from nerve centers as the source of the persistent striving of the learner?

This fourth factor is in line with the traditional view and with the prejudices of common sense. Those of us who feel that we "think in our heads" will be prone to physiologize the process in which we seem "motivated by an idea" in neural terms: we shall think of nerve centers discharging to the muscles, and of the cortical activity as primary. But we shall find scant physiological support for our notion. Everything that we have learned of the action of the nervous system tends to deny this view. The nervous system transmits and coordinates, but we know nothing of its power to originate impulses; and as for the central nervous system serving as a "house" for the mind, that is simply a survival of Hippocrates and Galen, and we have already seen on what inadequate grounds these conceptions arose. To be sure, the posture would "fall apart" if the neural arcs were cut, but to cut these arcs would be to break the stream of stimuli originating in exteroceptor, striped muscles, and viscera. There is, therefore, no reason for positing a fourth physiological source of motivation.

Drives Used in Learning Experiments.—To turn from these theoretical questions to the more practical one, "What drives are commonly employed in learning situations?" we may make the discussion concrete by naming some of the devices widely used. By far the most common drive in animal experiments is that of hunger. By withholding food for definite intervals, and by feeding under specified conditions (only when the task-to-be-learned has been completed), animals are taught a variety of habits. In addition, punishment (for errors), confinement (within enclosure from which the animal strives to escape), cold (with warm-blooded animals), water (for land animals), dry surfaces (for water animals), and thirst have all been used. The sexual tension has been utilized (with access to member of the opposite sex as the release), and in the case of the rat mother the tension induced by taking her away from the litter (with access to litter serving as release). Light, in the case of the negatively phototropic earthworm, was used by Yerkes to induce his worm subjects to run a maze (illustrating the third type of motivation). One investigator found that none of these motivating conditions worked with one of his chimpanzee subjects who would

work at the assigned task only as a means of getting back to play with the other animals. With human subjects the "sets" or "tensions" are characteristically induced by verbal means (at least above the level of infancy) and spring from the habits and desires developed in social situations. With small children a cooky or other desired food object has formed a suitable objective in many learning experiments; but at the school level the releasing stimulus is more likely to be praise or recognition of accomplishment, and the associated advantages which such recognition implies.

Concerning the relative efficiency of the different drives little can be said, save that the value of any given type of motivation will be relative to the animal studied and to the conditions in which it is employed. Where the discriminations to be taught are very simple, rates of learning increase with the intensity of the motivation used (*e.g.*, hunger, thirst, punishment), but for the more delicate and complex activities there is a point beyond which an increase in intensity introduces confusion and slows the rate of progress. Any attempt to rate hunger as against sex, or thirst, must—in the nature of the above generalization—be futile (there are *n* degrees for every drive). The negative type of motivation is to be used with caution because of its tendency to spread to other parts of the activity than the one whose elimination is desired. With human subjects, where control over the basic needs is seldom possible, only an alert and flexible program which constantly adjusts the type of motivation to the individual, and to the performance which is being obtained, can succeed in eliciting the maximum achievement.

The Block.—Any obstacle placed across the path of direct release of the motivating tension will serve as a block. Mazes of a wide variety of description ranging from simple T- or Y-shaped paths, with one true and one false turn, to an extremely complicated network of alleys have been used. An adaptation of the maze problem for human subjects, in which the latter trace a grooved (or raised) path with stylus (or finger), permits comparison of human and animal performance. Boxes (with objectives inside) which may be opened by latches, levers, strings, or platforms (to be depressed) and cages (within which the animal is confined) with similar modes of escape have been employed. In one of Thorndike's experiments the investigator waited until his cat subject turned to lick its side, and then released the animal; and while this solution appears artificial and arbitrary, the manner in which the animal achieved a way

of surmounting the "block" to its immediate satisfaction of hunger (fish was placed on a plate outside the cage) was comparable to the other "natural" situations. That is to say, the "correct" movement which finally occurred in a series of random trials began to appear earlier and earlier in the series until it was made as soon as the animal was confronted with the problem. In the end this movement was abbreviated to a brief gesture—a backward flexure of the head and neck gave the operator the signal to open the gate.

In short, the variety of "tasks" is limited only by the ingenuity of the investigator in setting up obstacles to the immediate release of an experimentally induced and controlled tension.

Random Movements and Chance Success.—The level of maturation and the habit repertoire of the animal set the limits for the trials. Acting under persistent stimulation, both internal and external, the animal's "possibilities of movement" appear in seeming random order until the accidental appearance of the releasing movement terminates the trial. The *variability* in behavior may be explained in part by the fact that the organism is a constantly changing thing, and in part by the fact that the external stimulus pattern also varies. The bars of the cage between which the animal attempts to struggle change from visual bars inviting approach to pressure and pain stimuli inducing recoil. The alley entrance, which invites the exploring rat to enter, changes as the exploring movements unroll into a shock grid (or dead-end wall), inducing recoil. Every movement changes the pattern of stimulation from the musculature itself, and also changes the relation between the animal and the field (so that changing external patterns play upon his receptors). The animal is thus figuratively thrown from one movement to the next. Neither the internal nor the external stimulating situation is constant. Add to this the fact that the exercise of a portion of the animal's repertoire alters the threshold of excitability of that portion (partial "fatigue") and we shall have no difficulty in explaining the "cut-and-try" character of the behavior on mechanical and physiological principles.

The *persistence* of the striving is due simply to the persistence of the motivating factors. The sight or odor of the food, the visceral state of hunger, the movable bars, levers, strings, latches, the "sets" or "expectancies" (postures) call for persistent, though variable activity. Occasionally the inexperienced rat in a complicated maze will turn to face washing or stop for a doze, but sooner or later

contracting stomach and tensed muscles will "poke him up" and the stimulating power of the maze will return.

Although the movements are here called "random," they are as definitely caused and directed as any animal response. They are random with respect to the goal, and the solution appears to be stumbled upon rather than foreseen. This chance character of the solution depends, of course, upon the degree of unfamiliarity which the problem situation has for the animal. Where old habits provide the animal with definite sets, expectancies, predispositions, his line of attack is limited, his behavior less random, and the whole activity looks quite purposive rather than accidental. In fact, his behavior equipment (and the arrangement of external stimuli, including the objective) may be such that the whole problem is rendered extremely difficult. Where, for example, the food lies just outside the bars of the cage, and the experimenter who has regularly fed the animal stands on the same side, a releasing mechanism (latch, platform, string) placed on the opposite side of the cage will be attacked only after considerable delay. Similarly, old habits of release may interfere with the task that is imposed. If the releasing movement is one which is rarely made by the animal, or if it depends upon a particular and complex sequence of movements, or if it is one which the present organic state or present external situation tends to inhibit, the problem will be a difficult one. Some animals, for example, show a distinct right-turn preference, and in such cases all mazes with the true path lying on the left will be learned more slowly. A chick, used in one of Thorndike's experiments, found a very simple maze difficult, simply because its interest in and striving toward other chicks kept its trials directed away from the correct solution.

From the standpoint of efficiency of training, the skill of the teacher should be directed toward an arrangement of stimuli which will make the chance success appear early in the series of movements. In the case of the act which involves a particular sequence of movements this may involve a dissection of the skill. In this case the last part of the act is taught first (the portion most closely attached to the release) and the total response is built up from the end to the beginning. Especially will this be necessary in all "roundabout" solutions, where the direct "pull" of the objective inhibits the indirect path of action demanded by the particular arrangements of the problem situation. The rule is, from simple to

complex, from easy to difficult, from direct to indirect, from end to the beginning. Such an order prevents confusion and discouragement (loss of motivation) and minimizes the interference of contradictory habits and postures.

Selection. *The Central Problem in Learning.*—The central problem in the trial-and-error view of learning is presented by the fact of selection. Most simply, the fact is that the random character of the learner's movements disappears, errors and false starts are

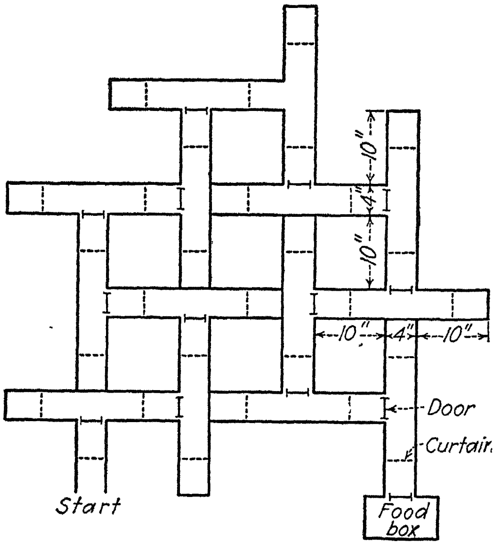


FIG. 63A.
For descriptive legend see opposite page.

eliminated, the blind and often false orientation is replaced by a "goalward" set, the time curve falls (sometimes gradually with many recessions, sometimes suddenly and with no recession). Particularly in the case of the inexperienced animal where it is impossible to give instructions, and where the learner has no means of "knowing" what it is all about, one witnesses a marked change in behavior after very few trials. Placed in the maze for the first time the rat novice may seem more interested in exploring than in satisfying his hunger. He climbs on the netting which covers the alleys and pokes about in the corners; he may backtrack, doze, wash his face, etc. With a trial or two in which he discovers the food box at the end of one of the paths his behavior changes. There is no dilly-dallying

now, and he scurries down the paths; though his performance is still full of errors, he seems to be intent upon the main business. To the autonomic state of hunger the early trials have added a more

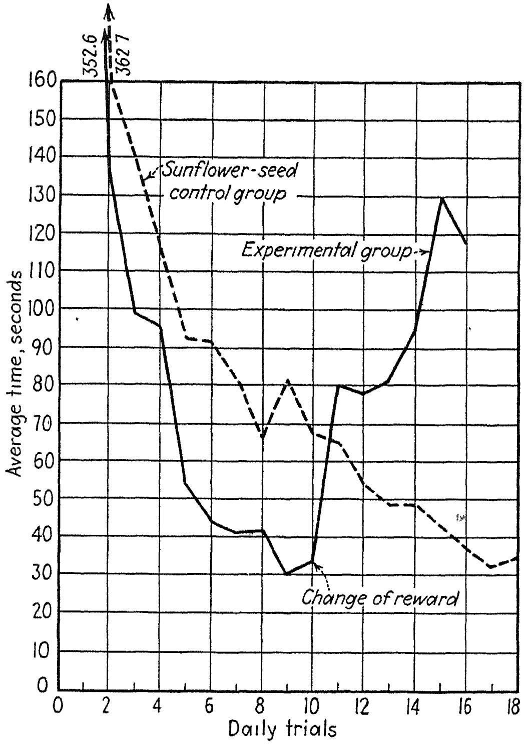


FIG. 63*B*.

FIG. 63.—*A*. A typical maze showing open pathway and blinds.

B. Curve showing fall in time with successive trials in maze shown in *A*. The broken line shows a less rapid fall in time than the solid one. This fact may be understood as indicating a relation between the selection process and the motivating conditions for the broken line represents the averages achieved by a group of rats fed on sunflower seed. The more rapid learners were fed bran mash until the tenth trial, at which point a less efficient reward was introduced. Curves based upon the record of errors show a similar relationship. (*From M. H. Elliott. The effect of change of reward on maze performance of rats. Univ. Calif. Publ. Psychol.*, 1928, 4, 19–30. *By permission of the publishers.*)

specific set or posture which in itself serves as a strong selective agent. The alley-to-be-explored has changed into an alley-beyond-which-lies-food. Beyond this point it is a question of eliminating the entrances into the blind alleys, and of smoothing out the sequence of correct responses until a continuously flowing chain of movements

carries him directly to the food box. The hesitant, halting, back-tracking behavior that appears to be segmental, loosely organized, is replaced by a smoothly executed whole.

A Mentalistic View.—How shall we interpret this process? At this point psychologists tend to divide, and the sharpest division of all is between those who would give a mentalistic explanation of the process and those who seek to explain the process in terms of mechanical-physiological principles. Since the mentalistic view is the older one and most deeply ingrained in human thinking, let us consider it first.

The mentalistic explanation appears in at least three forms: selection may be attributed in a most general way to the action of a mind or consciousness, or to some mental "power" such as attention or to some conscious quality of the correct responses, as, for example, satisfyingness, pleasurableness, vividness.

Consciousness as a Selecting Agent.—In the first type of explanation the learner is viewed as stumbling into the correct performance and then as discovering and purposefully adopting the "short cut." In the Gestalt psychology (which we shall consider more in detail later) this "insight" into the nature of the problem and of the relationship between "means and end" is made the primary factor and is commonly described as occurring before the correct response appears; but in the traditional trial-and-error description the correct integration is viewed as one stumbled upon, as occurring by chance rather than by design, and *then* selected by consciousness. Thus Swift writes: "Consciousness discovers modes of action already in use, and selects some of them for survival because of their success."[1]

But in Swift's own studies this recognition of the successful response is often belated, the correct integration having been in operation for some time (days, actually) before the recognition occurs. Where this is the case the selection process seems to be actually over before a tardy consciousness awakens to what has taken place. And so long as the mind or consciousness in which this awareness dawns remains something of a disembodied spirit we are totally in the dark as to how it operates upon the body's levers; nor are we told anything of the conditions which limit such awareness, nor as to why the correct components are selected and organized instead of the incorrect ones. And often as not the skilled performer's analysis

[1] Swift, E. J. Studies in the psychology and physiology of learning. *Amer. J. Psychol.*, 1903, 14, 201–251.

of what he does is quite faulty; to be sure, he "has the hang of it" and can repeat the act on request, but he is unable to communicate a correct description of the process to others. Many a successful singer (and for that matter, teacher of voice) has a totally false conception of the breathing movements in singing and would give false recipes for tone production, in spite of the fact that correct breathing and tone production lie within the command of these performers. As a matter of fact, we do not know the musculature involved in the simplest acts—for example, lifting a fork to our mouth. How can consciousness be responsible for the selection and coordination of a particular constellation of muscular contractions, when we know neither the names, location, number, nor degree of activation of the contracting members?

Attention and Selection.—The second variety of mentalistic interpretation refers the selection of the correct response and the elimination of the errors to the power of attention, to the vividness of the releasing action. Now, it is natural that attention should be invoked, for is not this process *selective* in its very essence? In the world of stimuli a few stand out and occupy the center of attention. What James pictured as the world of the child ("a blooming, buzzing confusion") becomes gradually—as we grow older—an ordered sequence of patterns. Shall we say that the attention process is ripening? Considered in this broadest sense, the development of the attention process *follows* rather than leads the process of habit formation. It is the skilled listener who can hear the pattern of the fugue or symphony; to the novice who knows nothing of musical forms it is a confusion of sounds. Moreover, when we look at the determinants of attention—the objective conditions of intensity, duration, change, contrast, etc., and the subjective conditions of posture, set, expectancy, "idea in mind"—are we not turning back to the conditions of motivation? The external stimuli and the internal states or postures, which activate and direct the trials of the animal, will also cause the selection of the correct response. Selection, we must conclude, is forced upon the learner by the very conditions which have prompted him to act in the first place.

Satisfyingness: the Law of Effect.—But why is the correct (*i.e.*, the releasing) response more vivid? Why is this particular spot in the maze singled out? Why are these activities able to make a deeper impression upon the animal, so that on subsequent trials they are retained in greater measure than the other actions which

occurred before them? Our third mentalistic interpretation would argue that it is the pleasurableness of the correct response, or its satisfyingness. One writer suggests that it is the advantageous character of the correct response which determines its selection. How a pleasurable effect accomplishes this is seldom revealed. A pseudo-physiological interpretation hints that "the effect of pleasurable sensation is a heightening of muscular tonicity"[1] and that this results in a greater "perseveration" of the response. Such a continuing "echo" of the reaction amounting to a continued innervation of the neural arcs involved would, of course, make a deeper "groove" in the conducting paths (if the traversal of a path by an impulse leaves a groove). But we still need to know why the pleasurable end result of a long series of trials can act back upon the series and deepen only those traces which are connected with the true path.

Consider a typical maze performance. Blind alleys as well as true paths are entered at the beginning, and retracing is mingled with forward progression. The "pleasure" which occurs as the food box is entered—if it is to reinforce the actions which have gone before—would tend to stamp in the whole collection of acts, good and bad, which have preceded. Are we not endowing this conscious state, pleasure, with remarkable powers and intelligence if we expect it to thread its way among the mixture of good and bad activities and nominate this one for a permanent place and that one for elimination? And how does it do it? Is there any heightened tonicity in conjunction with pleasure that cannot be duplicated in connection with pain? Isn't the animal's musculature under strong shock tensed enough? One theoretician proposes a kind of "heightened metabolism" under pleasure, so that whatever neural changes occur at this juncture would tend to be in greater amount than under other conscious states;[2] but both the heightened metabolism (like the heightened tonicity) and the neural changes are highly speculative; and neither of these pseudo physiologies meets the problem raised by the retroactive character of the process.

Logical Difficulties of the Mentalistic Explanations.—We may summarize the objections to these consciousness theories, then, as follows:

[1] Swift, E. J. *Mind in the making*, p. 186. New York: Scribner, 1908.

[2] Cf. discussion by Pillsbury, W. B., in his *Fundamentals of psychology*, p. 277. New York: Macmillan, 1934.

1. All of them involve us in an apparently insoluble problem: how can a non-physical consciousness act upon the body's levers? To separate mind and body and then to use the disembodied mind to explain the body's activities throws us back to animism. This false splitting of the individual into two parts is the original methodological error.

2. All these accounts fail to explain how a retroactive process selects only the correct coordinations.

3. The physiological hypotheses of heightened tonus or increased metabolism will not bear examination.

4. The consciousness type of explanation is of little help in a comparative psychology which deals with the learning of the lower animals. We know all too little of human consciousness; the consciousness of brutes is completely inaccessible. We may add the observed fact that the conscious recognition of the correctness of a coordination is often belated, and *follows* a preexisting selection process. It is also true that in testing reaction time or delicate discriminations in the laboratory the subject often "jumps the gun" or hits upon some minimal cue which leads to correct reactions, in spite of the fact that he is totally unable to locate the stimulus to which he is responding. Extreme precautions are necessary to isolate the stimuli and to confine the subject to those cues to which he is supposed to respond. Where, as in the reaction-time experiment, the subject repeatedly jumps the gun, and neither subject nor experimenter is able to isolate the cue to which he is responding without exhaustive search, we can scarcely credit consciousness with the selective power.

Frequency and Recency as Determinants of Selection.—These facts have persuaded the behaviorists that the correct place to look for the determinants of the selection process is in the objective conditions of the learning situation. At one time Watson believed that the entire process could be accounted for on the basis of two principles—*frequency* and *recency*. The principle of frequency asks us merely to assume that repetition tends to fixate an action pattern. Like the wrinkles in our face produced by the repeated folding of the skin in frowns or smiles, the interneural connections at the synapses will show structural changes which register the paths along which impulses have repeatedly traveled. On the basis of this generally accepted (but now seriously questioned) physiology of neural action Watson proposed to establish his first principle of selection. Granting the general principle, the experimenter's task consisted in demonstrating that in the learning situation the correct response inevitably occurs more frequently than others.

On the face of it Watson's guess is correct, for the correct response must be performed each trial. The trial does not conclude and the tension is not dissipated until the releasing stimulus (or act) appears. And the correct response is the only one which has to appear each

time. If the animal's repertoire be thought of as consisting of the responses *a*, *b*, *c*, *d*, *e*, *f*, *g* . . . *n*, the first trial may call out *a*, *c*, *e*, *f*, and *n* (the correct one); the second trial may call out *b*, *d*, *f*, *g*, and *n*. Moreover, when *n* occurs (and there is no reason why it cannot occur early in the series) the trial is terminated and the other unexcited responses are not given any exercise.

Logical Difficulties.—Against this view, however, objections have been raised, both logical and experimental, and they appear conclusive. If the frequency factor operates at all, it can be but a minor factor, and learning may take place where the frequency factor would seem to preclude it. To begin with, there is nothing to prevent any of the other responses from accumulating a frequency value and

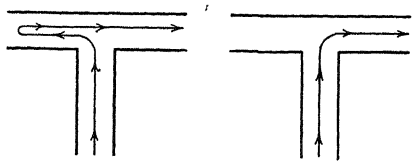


FIG. 64.—Diagram illustrating two patterns of response in T maze. The lines with arrows indicate the path taken by the animal. At the left (*a*) the false turn and retracing results in an altogether different succession of movements from the one shown on the right (*b*) where the correct turn is made. If the animal were placed in the maze 100 times by chance half would fall into the *a* pattern (T path) and half into the *b* pattern (inverted *L*). Frequency would favor neither pattern.

thus fixating errors. To this the Watsonian need raise no objection; in fact, it militates rather against the mentalistic and teleological explanations (which speak only of the fixation of successful responses). It is a fact that certain errors get stereotyped; all of us possess these in our most common habits, for example, speech and handwriting. But the error in the frequency explanation becomes more glaring when we simplify the conditions. Let us consider the simplest type of maze, the T maze such as Yerkes used on his earthworms. Here the animal is confronted with a simple pair of possibilities. A Watsonian might argue that in any case the correct turn must be made and that if the turns occurred on a purely chance basis—half to the right and half to the left—and if the right turn proved to be correct there would still be a possibility for the frequency explanation, since in any case, even when the animal turns left, the right alley must be traversed before the run is completed. But what takes place? Assume, if you will, to simplify the condi-

tions, that there is no retracing and that the worm must turn either to the right or to the left and then back on the right alley. This would give us two paths, one shaped like an inverted L, the other like a T. But if these occurred on a chance basis merely, in two hundred trials there would be a hundred T's and a hundred inverted L's. There is no frequency factor here to accomplish the selection. It would appear, rather, that of the two responses one is somehow *weighted* and the other, which interferes with it (an antagonistic response), is inhibited. This throws us back upon (1) the motivating circumstances and (2) the mutual inhibition of antagonistic patterns. The principle of frequency has failed.

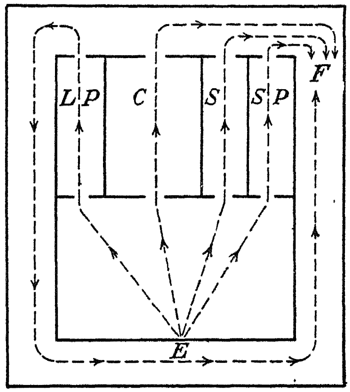


FIG. 65.—Plan of Kuo's maze. In the experiment the compartments were rearranged for different groups of rats so that no type of "effect" would have the advantage of any one position. *LP*, long path, *SP* short path; *C*, confinement; *S*, shock; *E*, entrance. (*After Z. Y. Kuo. The nature of unsuccessful acts and their order of elimination in animal learning. J. comp. Psychol.*, 1922, 2, 3. *By permission of the publishers.*)

Kuo's Experiment.—Even more convincing than the logical argument is an experimental study by Kuo.[1] He arranged a maze with four paths leading from the starting box: (1) a blind alley in which the rats met with an electric grid and were shocked; (2) a path which, though spatially fairly direct, contained a chamber in which the animals were confined for a period before being released to continue toward the food box; (3) a long path, unobstructed; and (4) a short, direct route. All of his animals finally learned the fourth route. The blind-alley-shock combination was eliminated first of all; the delay and long paths following in order. The two latter paths were "selected" by some of the animals for a period, and these animals—for whom the frequency factor alone would operate to keep them forever on the level of this inferior performance—form the final refutation of the frequency hypothesis. In spite of the frequency factor they moved to a new level. So it would be with a compositor who had formed inefficient habits of setting type and—

[1] Kuo, Z. Y. The nature of unsuccessful acts and their order of elimination in animal learning. *J. comp. Psychol.*, 1922, 2, 1–28.

under the stimulus of a bonus or some time-study scheme which clearly revealed his inefficiency—suddenly was able to show improvement. In fact, getting over any bad habit involves us in overcoming the frequency factor; if we were not able to do this, the neurotic and hysterical would be condemned forever to remain in the "abnormal" category, and the psychiatrist who dealt with these habits could only advise his patients to accept them with natural piety.

The recency factor meets a similar fate. Following logic again, the correct response is the *last* to be made in any trial. If the second trial immediately follows, the perseverating correct response will have an advantage over the other coordinations, and hence will tend to move forward in the series. But where trials are spaced at intervals of a day or longer the differences between the temporal intervals of correct and incorrect responses seem inadequate to account for selection, and there is noted no decline in learning efficiency with such spacing. Moreover, in an experimental setup like Kuo's the learning is against both frequency and recency factors. And it is equally true that every improvement must be made against the recency factor.

Automatization vs. Selection.—That there is an automatization factor which may be explained on the basis of the frequency and recency principles is entirely possible. For example, it is wise to break the sequence of trials when an animal develops an inferior solution, if efficient learning is desired. When, on a given day, the first few trials portray a persistent error, one can usually gain time by abruptly terminating trials for that day. After the error has had opportunity to "wane" for a period of twenty-four hours it is less likely to appear, and the new repetitions more likely to bring about progress. The coach sometimes advises the player who has "gone stale" to drop the game completely for a while, with similar advantageous results. Likewise, when we try to remember a name we sometimes find that dropping the whole matter is better than persistent search, for our original error gives a persistently false direction to our whole search. There can be no question as to the reality of perseverating states; but we are still very much in the dark about their role in learning, particularly in selection. And experimental studies show that the principles of frequency and recency must be subordinate to some other factor.

This other factor commonly goes by the name of the "law of effect." The original statements of this law were in the mentalistic

form: the vividness (attention-getting power) of the correct response, or its satisfyingness, or its pleasurable character was supposed to explain the selection process. We have already examined these and found them wanting. How can the law of effect be restated so as to avoid some of the weaknesses of the mentalistic view and to achieve a closer integration with physiological principles? Most broadly conceived, the *effect* of the occurrences in a trial is to make the next trial more efficient; that is merely a statement of the obvious. But what particular occurrences are crucial?

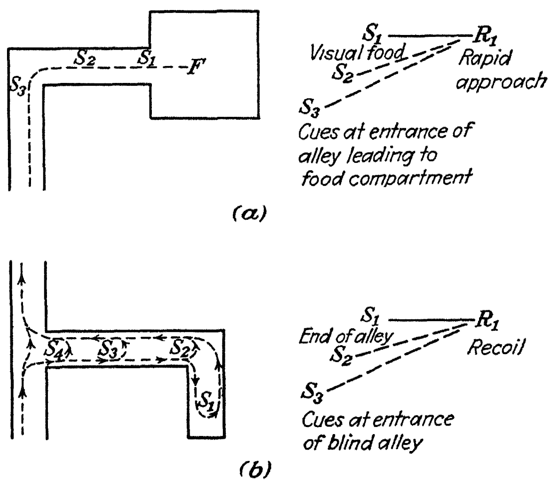


FIG. 66.—Diagrams illustrating a conditioned-response view of selection. S_1, S_2, S_3, represent the combinations of sensory cues which precede either the consummatory stimulus or the end of a cul de sac. Behavior which is at first attached to food, or to the end of the blind, is viewed as spreading back into the maze, and is aroused earlier and earlier as these preceding stimuli come to evoke (through conditioning) anticipatory adjustments.

A Restatement of the Problem of Selection in Objective Terms.—An objective account of selection will stress three factors: motivation, conditioning, inhibition of antagonistic responses.

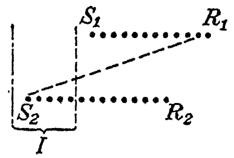
1. *The Role of Motivation.*—The factors which have introduced the tension which lies back of the persistent activity of the learner also introduce differences in the stimuli which confront the animal. The thirsty animal confronted with food and water is more affected by the water stimulus. Unless such a preferential hierarchy of stimuli is introduced by some motivating tension, there is no selection. The animal may run about in the maze for days on end; but without some motivation, some directional trend, his behavior

remains variable and random to the last. The motivating conditions, then, render certain stimulus-response relations more intense, and their resulting residues are correspondingly more permanent.

2. *The Fact of Conditioning.*[1]—At first it is the releasing stimulus itself which sends the hungry rat scurrying into the food box. But on subsequent trials the same reaction is induced by the temporally and spatially adjacent stimuli. The configuration of stimuli presented by the turn just before the food box acquires a reaction-inducing potency originally held by the releasing stimulus only. Thus, if we picture the portion of the path leading into the food box (as in Fig. 66*a*), the "approach reaction" originally induced by the food (*SR*) spreads back to S_1, S_2, S_3, etc.

A similar type of conditioning operates to eliminate blind alleys. If we picture such a "blind" as in Fig. 66*b*, the recoil of the animal, which at first occurs at the alley end (controlled by the walls or grid), will tend to occur earlier and earlier (in response to S_1, S_2, S_3, etc.) until the alley is not entered at all.

Now, it can be shown experimentally that where a delay is introduced between two stimulus-response arcs which are activated in pairs, as in the formula



the establishment of the connection S_2——R_1 becomes increasingly difficult as the interval S_2-S_1 is lengthened. This would mean, applying the facts to the maze situation, that the potency of the releasing stimulus would tend to spread back into the maze, and the maze would be learned from the end forward, and that selection (elimination of errors) would occur first in the area about the goal. Numerous investigations have verified this expected order,[2] and this fact suggests that conditioning of the type we have

[1] For a more extended treatment of conditioning see pp. 399–419.

[2] Certain exceptions must be noted. The general change in maze behavior on the second or third trial, noted above (in which the animal's reaction to *all* alleys is changed—it now seems preoccupied with the main business of getting food), is not confined to the goal area. There is also noted a general orientation toward the goal box. Errors (blind alleys) pointing in the direction of the goal

been discussing must form the basic process in trial-and-error learning.

3. *Inhibition of Antagonistic Movements.*—It is impossible to approach and recoil at the same time. One of the two will dominate, or some third response will capture the musculature. Couple this fact with the conditioning explanation of blind alleys given above, and the additional fact that the motivating tensions render one system of movements dominant, and the account of selection seems reasonably adequate. Selection may be explained on physiological principles; we need not appeal to any mental factor.

We can illustrate the role of the inhibition factor by an old experiment by Triplett.[1] This investigator trained perch not to strike at minnows by interposing a glass plate between perch and minnows. The fish's tendency to "strike" led regularly to a bump on the nose, and a recoil followed. The minnow stimulus now had a pair of competing tendencies attached to it. The perch could not both strike and recoil, and under the conditions imposed, the recoil reaction came to dominate; in fact, when trained, the glass partition could be removed and the minnows swam unharmed among their natural enemies. But such a state of affairs was unstable. Let the perch be sufficiently hungry, let the strength of the habit established by the conditioning fall, and one successful "strike" and

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are eliminated with greater difficulty than alleys pointing in the opposite direction. Neither of these exceptions, however, contradicts the conditioning interpretation; the alley character and the goal location involve configurations of stimuli found in close spatial and temporal relationship with the releasing stimulus. An exceptional case arises in the case of human beings in maze learning. Here the order of elimination is complicated by superior motivation, superior discriminations, and by the fact of verbalization. The human subject who fully appreciates the nature of the problem may undertake a certain trial with some such accompanying verbalization, "Now *this* time I am going to go to the right and *then* to the left," and if the trial turns out well this "right then left" formula can be followed again. The human being who can thus "take in" the whole maze situation at a time is able to relate the earlier responses in the series to his final performance; and as a result his order of elimination of errors shows that the maze is learned earliest *at the beginning and at the end*, first of all, and that the middle portion is learned last. But this case, likewise, does not dismiss the conditioning formulation, since the human being's habit of verbalizing carries with it the ability to lift out and retain the earlier movements and to bring them, at least symbolically, into close relation (temporally) with the releasing reaction.

[1] Triplett, N. The educability of a perch. *Amer. J. Psychol.*, 1901, 12, 354–360.

seizure (with no recoil-inducing bump), and the whole training procedure would have to be repeated.

Again, if we take the last blind alley just before the turn-to-the-food, we can see the inhibition factor working in conjunction with the conditioning factor. Opposed tendencies which cancel each other are at work at the entrance to the blind alley. After several entries, followed by recoil, the loopings grow shorter, and a mere "hesitation" at the entrance results. In the meantime the "food-

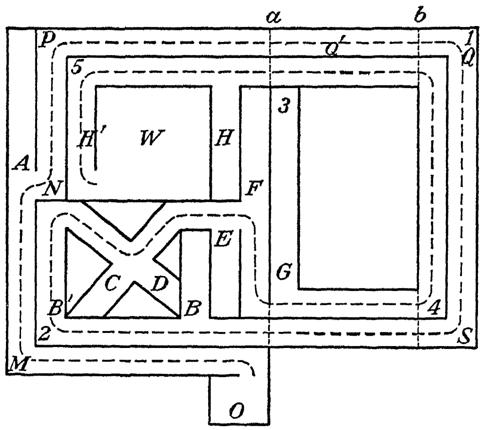


FIG. 67.—Carr-Watson maze which can be lengthened or shortened without altering the sequence of turns. By cutting the maze at the dotted lines *a*, *b*, a removable section was obtained. Its insertion or removal lengthened or shortened four alleys (in the shortened form *Q* occupies the position of *Q'*). Other alleys remain unchanged. Note that if kinesthetic cues from the run from *S* toward *B'* come to be regulative of the turn down *B'* through training in the short maze, lengthening the maze should induce turns into the cul de sac *B* (since *S-B* in the extended maze equals *S-B'* in the shortened maze). (*From H. A. Carr and J. B. Watson. Orientation in the white rat. J. comp. Neurol. and Psychol.*, 1908, 18, 27–44.)

approach" response is marching back from the goal. When the weak approach tendency is added to the "hesitation" response the latter is inhibited. If the motivation is maintained (and the food-getting tendency kept at full strength), this will result in a smooth course of movement past this entrance. Here we see all three factors at work: inhibition, conditioning, motivation.

It should be added that most successful learning occurs where the motivation is kept at high level, where the releasing stimulus is closely attached to the correct movement (where there is no delay in feeding, for example) and where the release is complete.

Fixation.—As the training process is carried beyond the point where the act can be performed without error, changes continue to occur. Most notable, perhaps, is the change in speed. The slow, halting, hesitant performance is changed to the rapid, smoothly flowing act. Movements which lie ahead are organized in advance; we can see the rat begin to wheel before the turn is actually reached. There is thus a telescoping and overlapping of movements, and the slow, controlled movement is replaced by the ballistic (or thrown) movement, and momentum factors are introduced into the coordinations.

Coupled with this change in the pattern of movement, there seems to be less dependence upon the external cue. Kinesthetic stimuli come to replace those from the distance receptors as controls of the movement. Carr and Watson[1] showed this neatly by changing the length of alleys after the habit had become automatized. The rats, as a result, ran into the ends of the shortened alleys, and they attempted to turn before the opening in the lengthened alleys was reached. We might diagram the shift in controls as follows:

$$\begin{array}{llll} S_1 \cdots\cdots\cdots R_1 & S_2 \cdots\cdots\rightarrow R_2 & S_3 \cdots\cdots\rightarrow R_3 & S_4 \cdots\cdots\rightarrow R_4 \\ \qquad\quad KS_1 & \qquad\quad KS_2 & \qquad\quad KS_3 & \qquad\quad KS_4 \end{array}$$

In the diagram, KS_1 may be taken as the kinesthetic stimulation which arises from the musculature as the first movement of the series (in response to S_1) is performed; KS_2, the kinesthetic stimulation from the second movement, etc. Under this situation conditioning will bring about the result whereby KS_2 organizes and activates the second movement *before* S_2 begins to operate. The automatic act is thus, in part, self-running; the internal cues have replaced the external ones, and the act is now bound together as a whole. What students of learning commonly refer to as the *higher units* are those segments of a habit which are self-running, in this sense. Thus, in learning to typewrite or to send code messages by telegraph, the operator may begin with separate letters, organize these into words, and later achieve the larger units of phrases and small sentences. The length of the unit which is unhesitatingly performed, and which functions without the need of external correction and reorientation, increases with the degree of practice and automatization.

[1] Carr, H. A., and Watson, J. B. Orientation in the white rat. *J. comp. Neurol. and Psychol.*, 1908, 18, 27–44.

Certain qualifications may be noted. In the first place, the decline in external controls is in the number of fixations, or correction adjustments, and not in the efficacy of the external controls. Habits never reach the point of being self-running in the sense that they are completely independent of the environment, and there are limits in the accuracy of movement, in the efficacy of kinesthetic control, which can never be surpassed.

In the second place, the diagram which we have just discussed might lead one to expect a rigid invariability in the performance of the automatized habit. Such invariability might fit in well with the conception of a habit as a point-for-point connection system across the synaptic junctions of the nervous system; but it does not fit the facts. Even our most automatic habits show variability from trial to trial; they may be performed in a variety of postures (and hence with varying kinesthetic stimuli); they involve different patterns of contraction when performed at different speeds.[1]

Finally, although the kinesthetic factors occupy a position of greater importance as the habit is automatized, an interference with these does not destroy the habit entirely, although the individual may be thrown back to the hesitant, controlled (rather than ballistic) performance. Operations upon rats which have automatized their maze performances, which so lame or paralyze them that altogether different patterns of movement must be used to traverse the alleys (hitching, rolling, limping, etc.), still leave the operated animals with the ability to traverse the maze without error. This fact raises serious questions for the account of conditioning, to which we next turn. It would appear that, instead of establishing fixed connections, instead of automatizing specific muscular patterns, the process of conditioning trains the animals to move from objective to objective, and that an almost endless variety of paths may be utilized to accomplish this end. The vicarious functioning which

[1] An unpublished thesis by Roger Sperry, of the Oberlin Psychological Laboratory, shows very neatly that such an act as drawing a circle involves vastly different muscular coordinations when performed at high speeds than when performed at low ones. In the former case the subject has to counteract the centrifugal momentum factors; and when the circle is drawn slowly muscles are innervated which counteract the force of gravity. (For example, when the subject bends over the circle to be drawn and allows his hand to hang above the center of the circle, he has to begin his movement by lifting the stylus to the circumference. This lifting is continued throughout the course of the slowly executed movement.)

Lashley and his students have demonstrated for the cortex would appear to be characteristic of the organism in learning behavior. If we achieve a physiological account of behavior that is finally satisfactory, the mechanisms which we portray must be as flexible as the facts of behavior demand. Chief among these facts is the learner's ability to achieve a functional end result (release of tensions) by a variety of means; and the added fact that the most completely automatized habits retain considerable variability, show different mechanisms at varying speeds, and are not destroyed when radical operative procedures force a shift to mechanisms never employed during training.

Since it appears to deal with the simplest conditions for learning, the conditioning process deserves close study; if any set of conditions will permit an understanding of learning in mechanical terms, the conditioned-response technique should reveal them.

The Conditioned-response View of Learning

The Establishment of a Conditioned Response.—The process of conditioning whereby new integrations are set up may be studied in connection with any stimulus which yields a clear-cut, measurable reaction. The reaction to be studied is called the unconditioned reaction. Thus, Pavlov selected the salivary response to meat powder placed upon a dog's tongue. An operative procedure which had led the duct of the gland to the surface of the skin permitted a record, in drops, of the amount of the secretion. Each time the meat powder was presented (inducing salivation) some additional reaction was invoked, as, for example, the reaction to buzzer, to metronome, or to the sound of bubbling water. This latter stimulus, referred to as the conditioned stimulus, is commonly presented just before the stimulus for the unconditioned reaction. As the two stimuli are repeatedly paired, a connection is gradually formed so that the presentation of the conditioned stimulus alone will evoke salivation.

Anrep's data, presented in Table 6, show an additional fact that is characteristic: as the strength of the conditioned reaction increases, its latency falls, *i.e.*, it moves forward.[1]

[1] The experimental precautions to which Pavlov and his pupils were driven in the attempt to achieve reliable quantitative results indicate the extreme delicacy of the process. Pavlov found it necessary to place the animals in a room where all conditions could be controlled. Stray sounds, shadows, odors, cur-

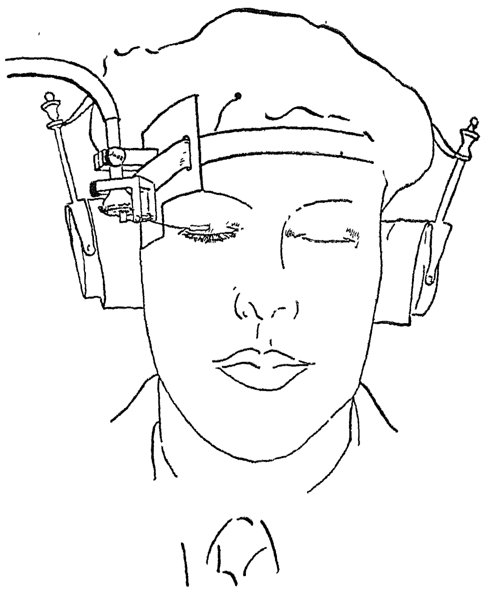


FIG. 68.—Headgear of subject in conditioning the eyelid. A tambour is mounted on the subject's temple by a strap which encircles the head. A light lever attached to the lid moves with each wink and converts the movement into a pulse of air in the pneumatic line which runs to a recording kymograph. Head phones were used to give the warning stimulus just before a shock was applied to the cheek, and soon came to initiate the wink before the shock was applied. *(From A. L. Bernstein. Temporal factors in the formation of conditioned eyelid reactions in human subjects. J. gen. Psychol.*, 1934, 10, 175. *By permission of the publishers.)*

The essential features of the technique are summarized in the formula

$$S_1 \xrightarrow[\text{Food (unconditioned)}]{\hspace{8em}} R_1 \;\; \text{Salivation}$$

$$S_2 \xrightarrow[\text{Sound (conditioned)}]{\hspace{8em}} R_2$$

where the line joining sound with salivation indicates the connection established by training. It should be admitted at once that this

rents of air, all disturbed the course of the conditioning. Moreover, unless the test situation duplicated that of the training period the conditioned response failed to function. Thus, he found that animals to be used for demonstration purposes had to be trained in the lecture-room situation. Furthermore, the intraorganic state proved just as important. Drowsiness, the persistence of previous disturbances (*e.g.*, sex excitement or other visceral disturbance) interfered with the process. And with new animals a period of habituation, in which their investigatory tendencies were free to exhaust themselves, was needed.

TABLE 6.[1]—RECORD OF THE ACQUISITION OF A CONDITIONED SALIVARY REFLEX BY ANREP'S DOG
(*From Anrep*[1], 1920)

Days	Paired stimulations	Strength of reflex in number of drops secreted in 30 sec.	Latent period
1	1	0	.
3	10	6	18
7	20	20	8
10	30	60	2
13	40	62	1
16	50	59	2

[1] Anrep, G. V. Pitch discrimination in the dog. *J. Physiol.*, 1920, 53, 367–385. Reprinted by permission of the publishers.

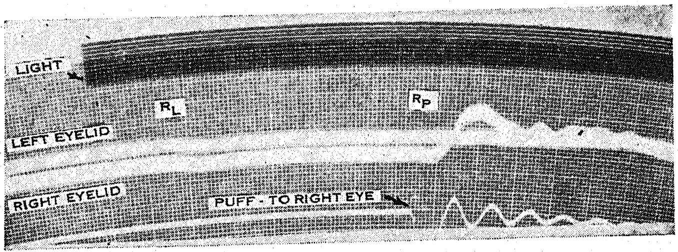
formula is simply a shorthand account of the technique of conditioning and in no wise represents neurological facts. The response to sound, R, is frequently neglected, since measurements are usually centered upon the conditioned response. That R_2 may be of considerable importance for conditioning theory will be indicated later.

In some cases the establishment of the S_2———R_1 connection results in the elimination of R_2. Thus, in one of the experiments reported by Pavlov,[1] two antagonistic responses were chosen, withdrawal from shock and the positive response (including both posture and salivation) to food. An electrode placed upon the foreleg of the dog supplied the conditioning stimulus and evoked the withdrawal of the limb. When the shock had preceded the food a number of times the withdrawal movement began to drop out and the dog held the positive food-approach posture without any sign of flinching or trembling. Pavlov reports that in similar experiments where "pricking" and "cauterization" were used careful records of pulse and respiration failed to reveal any trace of disturbance to the shock. The response to the shock had been inhibited. Triplett's experiment, mentioned earlier, is an example of the same sort.

That this is not a necessary feature of the process is shown by numerous instances where both R_1 and R_2 occur in the test situation. Thus Hilgard and Marquis,[2] who used a flash of light as the warning stimulus and a puff of air to the eye as the unconditioned stimulus

[1] Pavlov, I. P. *Conditioned reflexes*, pp. 29–30. Oxford: The Clarendon Press, 1927.

[2] Hilgard, E., and Marquis, D. Acquisition and retention of conditioned lid responses to light in dogs. *J. comp. Psychol.*, 1935, 19, 29–58.



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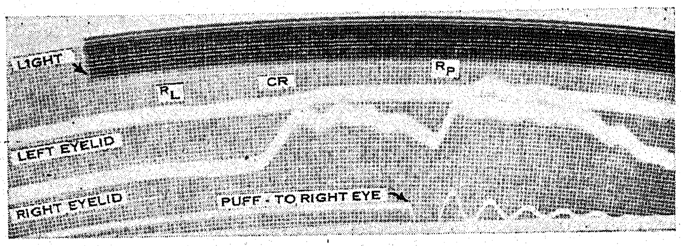

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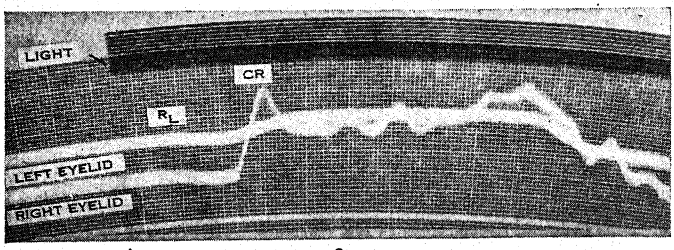

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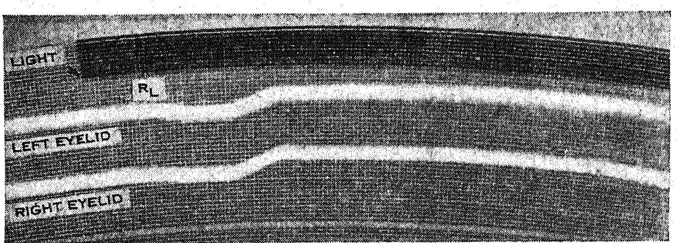

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FIG. 69.—Specimen records of the conditioning process. In (1) the right eyelid line shows two reflexes, a slight reaction when the light is turned on (darkening at top of record) and a reaction to a puff of air. (2) A conditioned response in the right eyelid line anticipates the puff, the latter stimulus serving to reinforce the response already going. (3) A conditioned response is initiated by the light. (4) The *CR* has been extinguished by repeating the conditioned stimulus without reinforcement. The slight reflex to light remains. (Downward motion of the lid line indicates opening, upward indicates closure. Vertical time lines, 5 ms., heavier lines, 50 ms.) (*From E. R. Hilgard and D. G. Marquis. Acquisition, extinction, and retention of conditioned lid responses to light in dogs. J. comp. Psychol.*, 1935, 19, 36. *By permission of the publishers.*)

for the eyewink, found that the warning stimulus also produced a slight lid movement. After the training series, the test records (taken without reinforcement by the puff of air) showed two lid reactions, a slight tensing of the lid 90 millisec. after the light, and the conditioned wink 80 millisec. later. Figure 69 shows that the two responses continue throughout the process.

This latter example should serve to warn us against viewing the process of conditioning as a mere substitution of stimuli or, as Pavlov thought, as the "result of diverting the nervous impulse from one physiological path to another."

The Time Interval.—Pavlov's original summary of his experimental work included an observation to the effect that it was possible to form conditioned reflexes if the conditioned stimulus preceded or overlapped the unconditioned stimulus (forward conditioning), but that if the reverse order was employed conditioning was impossible. Observations were reported in which over 400 repetitions of a pair of stimuli, in the backward order, failed to elicit the conditioned response, whereas but 20 repetitions established the response when a forward order was employed, and this held where the interval was of the order of one second. Recent investigators have shown that it is possible to establish the backward association, but all agree that it is more difficult to do so, and in most cases the connection, once formed, is highly unstable.

Not only is the forward direction the favored one, but the interval of from 250 to 500 millisec. seems the most favorable. When the interval falls below 200, contrary to what one might expect, the percentage of conditioning begins to fall. The first rough formulation of the law of conditioning in terms of contiguity of stimuli, paired presentations, neglects clearly established facts. It is entirely probable that this fact will throw some light upon the exact nature of the underlying physiological processes. The most obvious suggestion would seem to be that in the conditioning experiment we are dealing with the integration of *reactions* and that, unless we separate our stimuli by time intervals which will permit the full development of the reaction to the warning (conditioned) stimulus, the integration cannot be formed.

The Delayed (or Memory) Reflex.—When longer intervals are used in the training series the conditioned response tends to occur approximately at the point where the unconditioned stimulus occurred during the training. Thus, Pavlov reports an experiment

(Zavadsky) where a three-minute interval separated the conditioning stimulus from the acid (conditioned stimulus).

TABLE 7.[1]—NUMBER OF DROPS SECRETED DURING 30-SEC. INTERVALS OF DELAY

First	Second	Third	Fourth	Fifth	Sixth
0	0	2	2	4	4
0	0	4	3	6	6
0	0	2	2	3	6

[1] From Pavlov, I. *Conditioned reflexes*, p. 90. Oxford: The Clarendon Press, 1927.

The figures show that the salivary response begins to come in before the full interval has elapsed, reaching a maximum at the full interval. Where short intervals are used this anticipation is especially prominent in the early part of the training. Here the conditioned response follows closely upon the conditioned stimulus and then slowly moves back so that its position approximates that of the adequate stimulus. Investigators agree that the longer intervals are difficult to establish. Krasnogorski[1] found that he was unable to establish them in children until their second year, and he found it a useful method of detecting retardation and defective development at an early age. Besides being difficult to establish, they prove highly unstable, especially in experimentation with animals, one repetition without reinforcement being sufficient to obliterate the new integration. Whatever the nature of the "storage" process which retains the effect of the first stimulus through an interval of time, it seems to be less specific in animals than in man, for numerous stimuli can be substituted for the one used in training and the response will be elicited. (Hunter's experiment on the delayed reaction shows this same inability to delay specific discriminatory postures.)

What Pavlov calls a *trace reflex* seems to be a special case of the delayed reflex discussed above. "One dog was given food at regular intervals of time; another had acid introduced into the mouth at the same intervals. After this had gone on for a little time it was found that food or acid was no longer necessary to produce the alimentary or mild defense reflex, but that these reflexes appeared spontaneously

[1] Krasnogorski, N. Über die Bedingungsreflexe im kindesalter. *Jb. Kinderheilk.*, 1909, 69, 1–24.

at the regular intervals of time."[1] In one case the interval was lengthened to 30 min., with success. No doubt the regularity with which we become hungry and prepare to eat at mealtime is an example of just such conditioning. And the same may be true in the case of the person who has very regular habits of rising in the morning.

Experimental Extinction.—One of the traits of conditioned reflexes which has puzzled many observers has been the instability of the connections set up. We count it as axiomatic that "practice makes perfect" and it would seem that, if conditioned reflexes are an illustration of habit formation (or, indeed, the basic phenomenon in habit formation—the groundwork and explanation of the latter), once a conditioned response has been set up, the repeated exercise of the "connection" by repetition of the conditioned stimulus should serve to fixate and strengthen the bond. That this is not true has been demonstrated by many observers. For example, Pavlov,

TABLE 8.[1]

Successive unreinforced stimulations	Latent period	Number of drops
1	3	10
2	7	7
3	5	8
4	4	5
5	5	7*
6	9	4
7	13	3

[1] From Pavlov, I. *Conditioned reflexes*, p. 51. The asterisk calls attention to the increase from 5 to 7 drops. According to Pavlov, this increase "definitely coincided with some small disturbance produced by the audience." Oxford: The Clarendon Press, 1927. Reprinted by permission of the publishers.

after establishing conditioned responses to the metronome in his experimental animals, tested the reaction by repeatedly presenting the metronome without any reinforcement (*i.e.*, without the accompaniment of the meat powder, unconditioned stimulus). The results, shown in Table 8, indicate that the bond between metronome and salivation is easily extinguished.

[1] From Pavlov, *op. cit.*, p. 41. Oxford: The Clarendon Press, 1927. Reprinted by permission of the publishers.

Again, the conditioned knee jerk which is very slowly set up, with perhaps 200 paired presentations, is frequently extinguished with two repetitions of the conditioned stimulus without reinforcement. Bernstein[1] found that the conditioned eyelid response, set up with 50 pairings of the shock to the cheek with a click in headphones, was ordinarily extinguished within ten repetitions. In the latter case there was a rough relationship between the rate of extinction and the frequency with which the anticipatory response (conditioned reaction of the lid to shock) appeared in the training series; but, whereas the conditioned reaction might appear in 90 per cent of the training trials, ten unreinforced repetitions of the click were sufficient to extinguish the reaction. Pavlov reports that extinction is more rapid where the unreinforced repetitions are not spaced. Thus he found that

With	2-min. intervals, it was extinguished in	15 min.
	4	20
	8	54
	16	incomplete in 2 hr.[2]

He further observed that repeated extinction speeds the process in subsequent attempts until finally a single repetition without reinforcement will suffice.

These characteristics of the extinction process show that it is more than a gradual forgetting. Indeed, it seems to be a very active form of learning, of learning what *not* to do. An additional phenomenon emphasizes the active character of the process. If the extinction procedure is pursued after the response fails to appear, something which we might call an "extinction below zero" occurs. This is demonstrated by the fact that responses so treated are more difficult to reestablish when the original conditioning technique is once more applied, and by the further fact that spontaneous recovery occurs more slowly and is less complete. This affords a clear parallel to the facts commonly noted in connection with "overlearning" (see Fig. 70). If we practice a selection that is being memorized beyond the point of perfect recall, while immediate measurements may not show its effect, the later reestablishment of the process will demand fewer trials in the relearning. The extinction seems to

[1] Bernstein, A. L. Temporal factors in the formation of conditioned eyelid reactions in human subjects. *J. gen. Psychol.*, 1934, 10, 173–197.

[2] *Ibid.*, p. 53.

offer the converse of the process. Extinction below zero demands a greater number of repetitions to reestablish.

Experimental Extinction and the Law of Exercise.—The facts of experimental extinction do not agree with the "law of exercise," as sometimes stated. Thus, Gates offered as one of the basic laws of learning, the statement: "Whenever a modifiable connection between a situation and a response is exercised, other things being equal, the strength of that connection is increased."[1] Unless we include the fact of reinforcement under the phrase "other things being equal," the law does not cover the case for conditioning. Nor

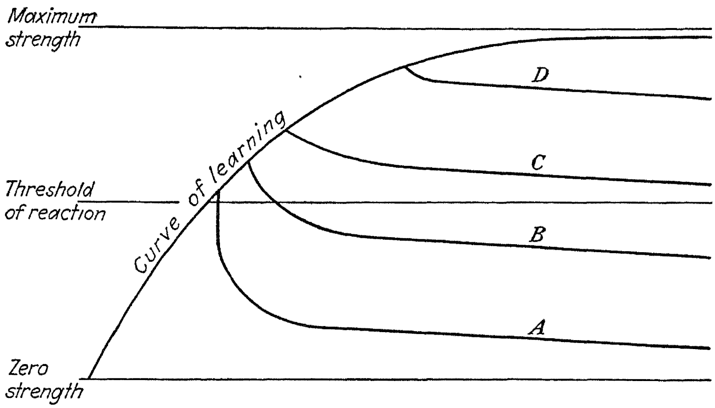


FIG. 70.—Curves indicating probable influence of disuse in the case of functions overlearned in various degrees. Forgetting tends to be rapid at the beginning and to progress at slower rates thereafter. In *C* and *D* the loss may fail to show at all in any ordinary test, because of the amount of overlearning. (*From A. I. Gates. Elementary psychology, p.* 331. *New York: Macmillan,* 1926. *By permission of the publishers.*)

are the facts of experimental extinction so remote from the phenomena of learning. The rat which has learned to dash through a complicated sequence of maze paths, discriminating blind alleys from the true path, will show all the facts of experimental extinction if the reward is removed from the food box for several successive trials. The responses which ran off rapidly as an integrated sequence slow up and the pattern undergoes disruption; the behavior of the animal reverts to the simpler random units of the earlier trials. Or, to choose another illustration, the vacation which frees us from the routine of classes and daily "reinforcements" of one sort or another

[1] From Gates, A. I. *Elementary psychology*, p. 282. New York: Macmillan. 1928. Reprinted by permission of The Macmillan Company, publishers.

disrupts our routine habits of rising, eating, sleeping. Similarly, our investigatory behavior at our new study table in the new room at the beginning of the college year (when the new blotter, texts, wall decorations, etc., have to be explored and examined) gradually gives way to the main channel of activities, and we become so habituated that the stimuli that were at first distractions now serve to support us in our study.

In his classic chapter in his *Principles of psychology* William James[1] described habit as an "enormous flywheel of society" and pictured it as keeping each of us at our professional tasks (in spite of irksome and repulsive details). Even society is preserved, he argued, from "the envious uprisings of the poor" by the bonds of habit which chain each of us to his allotted place. The establishment of character, of personal and professional mannerisms, he compared to the setting of plaster which, once dried and fixed, never softens again.

John Dewey,[2] too, has written in similar vein, speaking of habits as "assertive, insistent, and self-perpetuating," and as guaranteeing the "maintenance of the hedges of custom."

Both Dewey and James present a view of habit which violates the picture presented by conditioned responses when one considers the fact of experimental extinction. The rigidity of habit (if conditioned reflexes are typical) is the rigidity of a supporting situation. Habit's seeming inertia disappears when the setting alters. Those who have witnessed the breakdown of a lifetime of training when the young soldier leaves home and community to go to war may well be puzzled if the James-Dewey view of habit be true. And the ease with which we adjust to new conditions of sleeping, eating, working, etc., testifies to the fluidity and flexibility of our habits; in short, too many facts fit into the experimentally revealed pattern (experimental extinction). We might well consider inertia and stability as the special problems and seek supporting and reinforcing conditions rather than rule out the conditioned reflex as the basic type of learning, merely because of its instability.

No one can question the biological advantage of the experimental extinction process. Besides facilitating speedy readjustment to changed circumstances, it helps the individual to discriminate between the essential and the spurious. Were it not for the extinc-

[1] James, William, *Principles of psychology*, Vol. I, p. 121. New York: Holt, 1890.

[2] Dewey, John, *Human nature and conduct*, p. 58. New York: Holt, 1922.

tion process, a few chance occurrences of concomitant changes would condemn us to a lifetime of error.

The Stability of Conditioned Responses.—Concerning the permanence of conditioned responses established in childhood, John B. Watson, whose writings have done much to popularize the conditioned-response view of habit, describes the method of producing conditioned fear reactions in young children.[1] The harmless rabbit, long a "playmate," is made an object of fear simply by being presented while the experimenter produces the fear-inducing stimulus (in this case the noise produced by striking a steel bar with a hammer). And, after observing that the child now "shows fear at the sight of the rabbit," Watson adds:

> I have started the process of fear building. And this fear of the rabbit persists. If you show the rabbit to him one month later, you get the same reaction. There is good evidence to show that such early built-in fears last throughout the lifetime of the individual.[2]

Since the "good evidence" is not produced, one is permitted to question its existence. The child of six has dropped scores of fears which he had at two. Watson himself has described an experimental procedure which rapidly eliminates them. And unless these conditioned reactions are quite unlike the typical laboratory product, they, too, will prove to be easily extinguished. The writer knows of one occasion when an experimenter, who was attempting to get a film of the process of setting up just such fears as Watson describes, had to stop the camera and recondition the child. The first repetition of the conditioned stimulus without reinforcement had extinguished the conditioned reaction:[3]

Conditioned Inhibition.—A special application of the experimental extinction technique demonstrates the active character of the inhibitory process set up. Pavlov was able to show that the failure of the response was not due merely to the severance of connections between the stimulus and the effector, but rather to the establish-

[1] Watson, J. B., and Watson, R. R. *The psychological care of infant and child.* Pp. 48–54. New York: Norton, 1928.

[2] *Ibid.*, p. 53. Reprinted by permission of the publishers.

[3] The observations of M. C. Jones which seem to indicate that mere repetition of the situation will not eliminate the conditioned fear, suggest that there may be unknown and uncontrolled factors present which provide the necessary reinforcement. For example, if the repetition is "forced" upon the child, the very method of handling the subject may provide the requisite reinforcement.

ment of a special type of response. For example, a conditioned response is set up to tone so that the latter, regularly reinforced by the presentation of food, comes to evoke the salivary reaction. If numerous trials are interposed in which the tone is accompanied by a touch, and the combined stimuli are never reinforced, the salivary response will finally fail altogether whenever the touch is added. More than this, other conditioned reactions will be blocked when the touch is presented in combination with otherwise effective conditioned stimuli. This last fact shows that the extinction technique has endowed the touch stimulus with specific inhibitory properties.

Inhibition of Differentiation: Generalization.—When conditioned reflexes are being set up, especially in the early stages, other stimuli within the same modality tend to evoke the reaction. Dr. Mateer,[1] conditioning children to react to a tactual stimulus (chocolate was used as the unconditioned stimulus, and the opening of the mouth the reaction), found that other dermal stimuli applied to remote parts of the body also evoked the reaction. When, however, the other stimuli were never reinforced (*i.e.*, followed by feeding of chocolate) they gradually lost their power, and the effective area was confined to narrow limits. The limit to which the technique can be pressed is determined by the differential threshold of the area. Thus, the conditioned-response technique offers a method of establishing differential thresholds in animals and children. Its application to adult human subjects is, of course, strictly limited, for the labor involved is prohibitive. The verbal report is simpler and more direct.

Experiments have shown that this irradiation tendency varies with the "remoteness" of the stimulus. This is best illustrated by the experiment where the tactual stimulus is used. Placing four vibrators on the body surface (shoulder, small of the back, thigh, calf), Bass and Hull[2] showed that, if the shoulder vibrator was used as the conditioned stimulus, the other vibrators would also evoke the response, but in diminishing intensities which paralleled the increase in distance from the stimulus used in conditioning. When the inhibitory irradiation was studied, similar relationships held.

In a changing environment our adjustments would thus seem to be a rather delicate balance between the processes of generalization

[1] Mateer, F. *Child behavior*, Boston: Badger, 1918.

[2] Bass, M. J., and Hull, C. L. The irradiation of a tactile conditioned reflex in man. *J. comp. Psychol.*, 1934, 17, 47–66.

and extinction. The generalization phase provides an ever-widening extension of the effects of local training. It provides ready-made diagnoses or definitions of the new situations which we meet. It is being constantly curbed and corrected, however, by the extinction process. Wherever the readily applied generalization fails to find support and reinforcement, inhibitions are set up, and thus we learn to discriminate the true from the spurious, true functional identity from superficial resemblance. The rudiments of human reasoning and intelligence are thus found in the properties of reflexes in animal behavior.

Disinhibition.—We have already seen that experimenters are able to secure reliable results only by an extremely careful control of all the conditions. The intrusion of extraneous stimuli interrupts the regular course of establishing a conditioned response. It is interesting to note that the same disruption is produced if the stimulus occurs during the development of inhibition. This time, however, the interruption produces the opposite result, that is to say, the course of the inhibition is arrested and the original response occurs.

The complications which are here introduced serve to emphasize the complexity of the conditioning process and the need of extremely careful procedures. When one adds to the factors of disinhibition the factor of spontaneous recovery during the intervals of no training, and the generalizing tendency, one can glimpse the enormous task before anyone who wishes to present a complete analysis of even a limited segment of human behavior. A new stimulus may inhibit a developing conditioned reaction, check an extinction process, tap a generalized reaction developed in an allied field (either excitatory or inhibitory). In addition, the moment at which the stimulus is applied is also important, for it will fall upon processes which wax and wane in time.

If, at times, we fall back upon a functional-teleological vocabulary and present "post-mortem" analyses instead of formulations with predictive values, it is not altogether surprising.

Second-order Conditioning.—It is possible to use the conditioned reflex as a new base of departure and to establish a secondary conditioned response without the reintroduction of the original unconditioned stimulus. Thus, if we condition an eyewink to light, and then use the light-wink reaction as a base, pairing some additional stimulus with the flash, for example, a buzzer, we can then produce the wink by administering the buzzer alone. The facts of

experimental extinction warn us, however, that the very act of establishing the second-level reaction will bring about a reduction, if not an extinction of the first conditioned response; and we need not to expect to pursue this compounding process indefinitely without reinforcement. It is also necessary that the first order be firmly established before proceeding to the other levels. Pavlov reports that one of his collaborators endeavored for over a year to establish a conditioned reflex of the fourth order without success, although the third order was achieved. As one might anticipate, the intensity of the reaction declines in the second and third orders, and the latent period increases.

Alterations in the Response Produced by Conditioning.—The conditioned response usually resembles but is not identical with the original reaction. Most striking, perhaps, is the altered reaction time. The conditioned responses listed in Table 9 are all shown to have longer latencies than the reflexes which provided the unconditioned reactions.

TABLE 9[1]

Investigator	Subjects	Unconditioned $S - R$ latency, millisec.		Conditioned $S - R$ latency, millisec.		Voluntary, millisec.
Cason	6	Shock-wink	126	Click-wink	172	239
Hamel	4	Shock-finger	100	Touch-finger	151–200	151–200
Schlosberg	3	Blow-kneejerk	40	Bell-kneejerk	403	443
Hilgard	2	Sound-wink	40	Light-wink	110–164	167
Bernstein-Miller	90	Shock-wink	40	Click-wink	105–1210	105–360

[1] Adapted from Hull's table, p. 430, *Handbook of experimental psychology.*

The fact that the latency of the conditioned reaction is similar to that of voluntary responses probably indicates that the conditioned reactions are routed over the longer paths through the cortex, rather than through the shorter spinal or brain-stem paths. The figures do not indicate, of course, that the reactions are any the less automatic. Often the subject will be unable to tell whether the reaction was made or not, and it is entirely possible to build up conditioned reactions of which the subject is quite unaware.

While in many cases the form of the conditioned reaction is roughly that of the unconditioned reaction. some investigators have

found conditioned responses which are totally unlike the original reaction. Even in those cases which show rough resemblance, as, for example, in the eyewink where closure of the lid is produced in both cases, distinctions can be made.

Bernstein, in conditioning the shock-wink reaction to an auditory click, frequently found a tensing of the eyelid muscles instead of the complete wink, a tensing which sometimes lowered the lid slightly, at other times raised it (depending upon whether orbicularis or levator dominated). Observing this "setting" of the lid, one is reminded of an individual assuming a semirigid posture in anticipation of a coming blow or shock, as when one sets himself to catch a heavy object thrown from above. One is tempted to describe such a case of conditioning as a process of establishing expectancies, anticipations. One sets up a preparation for the stimulus-to-come, a preparatory posture which does not duplicate the full reaction and is not fully discharged until the releasing stimulus appears. This posture will serve as a background that will modify whatever reactions the situation calls out, but it may be quite insufficient to discharge the complete reaction (*e.g.*, wink).

So, too (as Tolman points out),[1] when Mary Cover Jones used the midmorning lunch as a conditioning device in ridding her child subject of his fear, she did not condition the child to eat the rabbit.

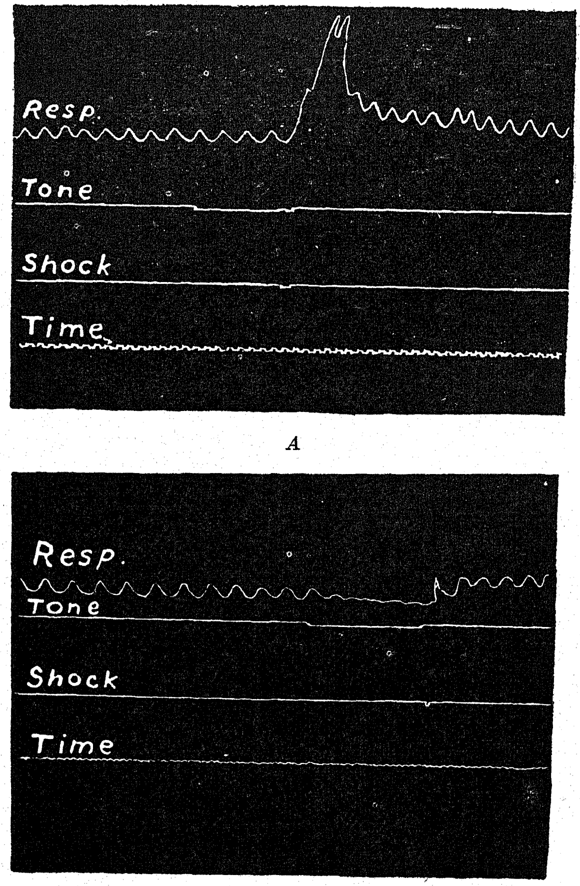
These facts make the original Pavlovian concept of conditioning seem too simple. Conditioning involves more than a simple neural switching so that a reflex becomes attached to a new stimulus. After all, it is the organism that is undergoing conditioning and the organism continues to adjust to a total situation. Sometimes this supporting situation will permit the discharge of a reaction closely resembling the reflex (though never identical with it); at other times different responses will appear, or overt behavior may be checked altogether. In the latter instance we seem to deal with an "expectancy"; while conditioning has "set" the organism for the stimulus-to-come, the full reaction will require the releasing stimulus.

This "expectancy" interpretation fits in with other findings. Wever,[2] using a tone-shock sequence, found that his cat subjects did not give the characteristic respiratory gasp when the conditioned

[1] Tolman, E. C. *Purposive behavior in animals and men*, p. 287. New York: D. Appleton-Century, 1932.

[2] Wever, E. G. The upper limit of hearing in the cat, *J. comp. Psychol.*, 1930, 10, 221–234.

stimulus was presented alone (see Fig. 71); instead, breathing grew shallow, as though the animal were attentively awaiting the impact



B

FIG. 71.—Respiratory responses in cats. *A*. Reflex reaction to shock. *B*. The "flutter" response produced by conditioning. The effect of training here recorded shows that the conditioned reaction may be quite different in form from the original reflex. Shallow breathing follows the onset of the warning tone. (*From E. G. Wever. The upper limit of hearing in the cat. J. comp. Psychol.*, 1930, 10, 227. *By permission of the publishers.*)

of the shock. Other investigators[1] were able to show that, if condi-

[1] Britt, S. H. Tonal sensitivity in the white rat. *J. comp. Psychol.*, 1935, 19, 243–264.

Upton, H. The auditory sensitivity of guinea pigs. *Amer. J. Psychol.*, 1929, 41, 412–421.

tioning was prolonged, the subjects occasionally gave the full gasp reaction, but such reactions were not typical; some investigators have failed to find them, and they appear to be very unstable.

Those who most sharply attack the conditioned-reflex formulation of the learning problem erect their case at this point. The responses which occur as a result of conditioning are not reflex; neither are they duplicates of the original (unconditioned) reactions. It is also true that calling the reactions "expectancies" does little to explain them.

The truth of the matter is that an experimenter never deals with an isolated reflex, but also with an organism; neither does he confront that organism with an isolated stimulus, but always with a situation. When we remember these facts we need not wonder that the conditioned response does not duplicate the original reflex in form and latency. It was sufficient for Pavlov to have demonstrated a technique by means of which one could reduce the process of habit formation to a set of laws; we need not follow his pioneering speculations as to the physiology of the process.

Conditioning and Motivation.—Students of the phenomena of conditioning have, as a rule, paid relatively little attention to the motivation of their subjects. To be sure, the salivation experiments of Pavlov would have given different results if the dog subjects had been fed just before being taken into the experimental room; and Pavlov remarks about the disturbing effect of any type of autonomic upset, and notes that the animals must be alert (and not drowsy) for efficient conditioning. But once an alert (yet calm) subject is strapped in the harness, the coupling of reflexes through the pairing of stimuli is looked upon as a fairly automatic process. The description of the process is not couched in terms of successes and rewards, or punishments and failures, and one is inclined to look to minute chemical and structural changes within the conduction system for the explanation of the process rather than to any "striving" or "release of tension." A human subject in the knee-jerk experiment may carry on a conversation, read a book, and in other ways portray complete indifference to the long series of buzz-blow sequences (in which the falling hammer to the tendon is regularly preceded by a warning buzz). In spite of his absorption in other reactions, the quadriceps contraction which throws the foot forward will come to anticipate the unconditioned stimulus as the conditioning process is carried out.

In witnessing such an experiment one gets the impression that we are dealing with something less than an intact subject. The more or less meaningless reflex reactions seem like fragments "chipped off" by the stimuli; and when we discover, on testing the conditioned responses, that they are highly unstable we are inclined to think that the lack of motivation, the lack of interest, the lack of supporting postures and tensions may have something to do with it. In Bernstein's eyewink experiment, for example, in which the subject sat passively while shock and warning click were administered, the median subject (out of 59 falling in the favored time intervals) showed 19 per cent conditioned responses (in a training series of 50 trials), but the stabilities were very low; 55 of the 59 subjects gave fewer than ten conditioned responses without reinforcement (the criterion being three failures to respond) and the median subject showed but one conditioned response before the extinction of the conditioned reaction.

Integrating the Conditioned Response with Well-established Acts.— In an effort to gain a greater amount of "participation" on the part of the subject and to study the effect of this change upon frequency of appearance and stability of the conditioned reaction, the procedure for the eyewink experiment was altered.[1] The subject was instructed to press a key as rapidly as possible when a warning stimulus was given, and in so reacting he closed a shock circuit which activated the wink reflex. Ten subjects following this procedure gave conditioned responses in 90 per cent of the 50 training trials, and stabilities increased markedly. Five of the ten subjects were still giving conditioned responses at the end of the experimental period, and the average stability obtained was 50.9. One interesting fact may be noted: close observation of the records showed the conditioned responses to be clustered about the hand movement. When the hand movement was rapid (and this was most obvious when the subject "jumped the gun" and pressed the key before receiving the appropriate warning signal) the lid movement was also rapid, and when the hand movement was delayed the lid was correspondingly delayed. Hand and lid appeared to be tied together. The lid response, instead of appearing as an isolated fragment of behavior, was clearly an integral part of a much more general reaction; and the

[1] Miller, Joseph, and Cole, L. E., The influence of a "voluntary" reaction upon the development and extinction of the conditioned eyelid reaction. *J. genet. Psychol.*, 1936, 48, 405–440.

increase in frequency and stability of the conditioned reaction under these circumstances points to the importance of supporting postures and tensions in the matter of conditioning.

The Performance of "Sophisticated" Subjects.—Equally convincing demonstration of the importance of postures, expectancies, and attitudes on the part of the subject is offered when sophisticated subjects are used.[1] As a rule, the subjects in the conditioning experiments are not too clear as to the meaning of the procedures employed. Many of the subjects feel that their intelligence is being tested, or their speed of reaction. And, as a rule, the maze of apparatus, wires, pneumatic lines, kymograph, vacuum tubes, etc., is simply a confusing jumble to the subjects. When the experimenter takes time to explain the apparatus and procedure and explains exactly what is going to happen—pointing out specifically that he will get a series of shocks from the key closures, and that from the point when the closure suddenly ceases to give him a shock he will get the warning signal alone—a radical change in results appears. Table 10 gives the number of conditioned responses appearing in 50 training trials and the stabilities which follow such training, when such sophisticated subjects are used in the same procedure (described above) which yielded such high stabilities.

TABLE 10.—FREQUENCY AND STABILITY OF CONDITIONED RESPONSES WITH SOPHISTICATED SUBJECTS

Subject	Frequency	Stability
L.E.C.	48	3
C.O.L.	41	4
K.U.E.	42	1
M.A.C.	34	2
S.M.I.	49	1
M.I.L.	46	3
R.A.C.	24	1
B.E.L.	34	5
S.U.R.	47	1
S.T.U.	48	1
A.Y.R.	46	26 (Stability on retest 11)
N.I.S.	50	54 (Stability on retest 3)
G.R.E.	40	69 (Stability on retest 5)

[1] The observations which are here reported are taken from an unpublished study carried on by Lloyd Beck and the writer in The Oberlin College Psychological Laboratory.

It will be noted at once that, while the frequencies with which the conditioned reaction appears during the training are high, stabilities have dropped sharply in all but three cases. Two of these, who were brought back for a retest (N.I.S. and G.R.E.) promptly dropped to stabilities of 3 and 5, and the third (A.Y.R.) dropped to 11. Six of the subjects listed had served as subjects in an earlier version of the same experiment, and as naïve subjects they achieved stabilities listed in Table 11.

TABLE 11.[1]—STABILITY OF CONDITIONED RESPONSES WITH NAÏVE SUBJECTS

Subject	Stability
R.A.C.	62 (No extinction achieved)
B.E.L.	80 (No extinction achieved)
S.U.R.	81 (No extinction achieved)
N.I.S.	70 (No extinction achieved)
G.R.E.	75
S.T.U.	13

[1] It is possible that the three subjects (N.I.S., G.R.E., and A.Y.R.) who failed to show low stability on first test as sophisticated subjects took the experimenter's statements with a "grain of salt" or perhaps paid little attention to them. It was not possible from their verbal reports to formulate a very clear notion of what they thought would happen; but the drop in their stabilities on retest suggests that some such factor as we have indicated may have been at work.

Conditioning and Expectancy.—These experimental facts serve to remind us that the usual account of the objective stimulating conditions (strength of stimuli, temporal interval, etc.) is not sufficient. The subject must be included in the description of the process, and his attitudes, expectancies, and interpretation and organization of the experimental events form an extremely important factor in the conditioning process. In fact, one is tempted—in view of the findings we have just reported—to say that the expectancy (or "insight") of the subject is an all-important regulator of the process. One is tempted to generalize and say that the subject's responses will be appropriate to the situation as conceived by him, and that this *understanding* takes precedence over the temporal-spatial-physical characteristics of the stimulating situation.

It is interesting to find this issue raised in connection with an experimental study of conditioning, and it affords an appropriate point at which to introduce the Gestalt view of the learning process. This latter view, which stresses the subjective and perceptual factors in the learning process, is clearly opposed to the Pavlovian account of things. In so far as our own conclusions emphasize the importance of the factors of meaning and insight, and stress the fact that it is the

"whole subject" (and not an isolated set of reflexes) and a meaningful situation which must be considered, our view of "conditioning" approaches that of the Gestaltist.

Before taking up the Gestalt description, two considerations are offered: one experimental, the other logical. As to the experimental: in carrying out observations upon the effect of an understanding of the conditioning procedure (cf. pp. 417–418) special test series were added, following training and extinction. The subjects were told that the warning stimulus would sometimes be followed by a shock and sometimes not, and that the two types of situation would be arranged according to a definite pattern. In the simplest arrangement a simple alternation was followed, and the subject was usually quick to detect the order and could report upon it. His lid response, however, did not reveal the presence of "insight"—that is, the expectancy of "no shock" did not always inhibit the wink, and the expectancy of shock was not always followed by wink. Although the subjects had a clear knowledge of what was taking place, their reactions did not reveal this. The subjective perceptual factor alone is not sufficient.

As to the logical consideration: our expectations are the outgrowth of experience. Recollection enables us to anticipate. We may thus look upon the two accounts of conditioning (objective and subjective) as complementary rather than mutually exclusive. As we have found elsewhere, in dealing with the purposive description of behavior, the objective account is most fruitful in describing the genesis of our motives and anticipations. Instead of opposing the two descriptions, may we not say that the Pavlovian description of the conditioning methods affords us with an account of the way in which our expectancies arise (and break down).

Gestalt Psychology and the Learning Process

The Stress upon "Wholes," Configurations.—For the past quarter century the contributions to the psychology of learning have been increasingly from the field of comparative psychology. Animals make docile subjects and permit rigid control of conditions, and they provide an opportunity to study both structure and function at a simpler level. It has been through this gateway that an increasingly mechanistic emphasis has been brought to bear upon our views of the learning process, for while psychology has been moving closer to biology, the latter discipline has joined hands with physics. The

conditioned-reflex view, which we have just discussed, represents one outcome of this influence.[1] In general, this physiological and mechanistic influence inclines the psychologist to be chary of all teleological descriptions, to reduce consciousness to something of an epiphenomenon if not to neglect it altogether (in contrast to the tendency of Wundt and Romanes, who seemed to be able to make introspective reports for their animals) and to view behavior as analyzable into rather simple units (the reflexes). Under this scheme the learning process—whether viewed as trial and error or as conditioning of reflexes—is simply a compounding of these reflex units into more complex combinations and sequences, a compounding *forced* upon the organism by the juxtaposition of external stimuli.

Against this increasingly mechanistic and physiological conception of the behavior of organisms one school has been consistently opposed, and in some quarters the Gestalt psychology[2] has seemed to offer the best defense against a "robot psychology." The organism, the Gestalt psychologist is inclined to say, is not simply a sum of its parts. One cannot add up reflexes and get a person. We are faced, rather, with an interacting system (or configuration) which is essentially irreducible, which has its own properties. To expect to derive the properties of organic behavior from the study of reflexes is like expecting to discover the properties of water from a study of hydrogen and oxygen. The whole is, in this case, not merely greater than the sum of its parts; it is something entirely new and other than the simple parts. And it is not merely in the description of the organism that psychologists have erred. The stimulus is never a simple physical quantity; it is always a stimulus-

[1] Although Pavlov viewed his studies as a means of getting at the physiological substrate of *consciousness*, the emphasis was upon the substrate, the approach a mechanistic one.

[2] Although Gestalt principles are much older, the emergence of a definite school may be said to date from 1912 with the publication of Wertheimer, Max. Experimentelle Studien über das Sehen von Bewegungen. *Z. Psychol.*, 1912, 61, 161–265. Presentations of the Gestalt viewpoint will be most accessible to the American student in the following works:

Koffka, K. *Growth of the mind.* New York: Harcourt, 1924.

Koffka, K. *Principles of Gestalt psychology.* New York: Harcourt, 1935.

Köhler, W. *Mentality of apes.* New York: Harcourt, 1926.

Köhler, W. *Gestalt psychology.* New York: Liveright, 1929.

Hartmann, G. W. *Gestalt psychology.* New York: Ronald, 1935.

Petermann, Bruno. *Gestalt theory and the problem of configuration.* New York: Harcourt, 1932.

in-relation—an object with meaning. Thus, the Gestaltist urges that in the mechanist's attempt to describe human behavior in terms of physics and physiology he has missed the peculiar properties of these organic and situational configurations with which he should properly be concerned.

We might sum up the Gestalt argument in the dictum: "Physical constancy is not equivalent to psychological constancy." To illustrate: we think of snow in the moonlight as white, and of black velvet in daylight as black, and yet the latter reflects a light to the retina of much greater physical intensity. It would appear that white and black refer to *relations*, and that the value of a stimulus depends upon its context. Illusions of size and color are produced by contrast effects induced by surrounding objects. Thus it would appear that the constancies with which the psychologist deals are *constant relations*. It is not the isolated physical stimulus that is important, but the stimulus-in-relation.

The same stress is applied by the Gestaltist in his description of the response. Just as we can produce the same melody at different pitches (it is the sequence of relations that matters), so we may identify the act of nest building in a bird, although the chains of reflex actions vary from individual to individual (depending upon the materials available, the objects to which the nest is to be fitted, etc.). Thus the constancy of the perceived object and of the subject's response to it is a constancy of wholes, of configurations, and not a mechanical type of identity constructed from rigidly conceived units.

A Different Type of Learning.—Now when this school of psychologists approaches the problem of learning it does not so much deny the existence of trial-and-error learning, or of conditioning, as it insists upon a different interpretation of the facts. It is the interpretations of Pavlov and Thorndike which they would discard. In fact, the Gestaltists are of the opinion that the examples which have been advanced by these investigators as standard types of animal performance are really highly specialized cases, quite unrepresentative of animal conduct in general. Some argue, for example, that the maze technique as ordinarily employed has been a most unfortunate tool. Not only are the problems usually far beyond the animal's range of comprehension, but the significant items are commonly beyond the animal's range of vision. He can gain no "grasp of the whole," no insight into significant relations, and his

blundering is simply eloquent evidence of this fact. Even man, who on occasion is a most efficient reasoner, placed in similarly confusing situations will behave as a blundering automaton.

Moreover, the type of "solution" which the Gestaltist considers as representative is vastly different from that of either Pavlov or Thorndike. Instead of the blind groping at the start, endless

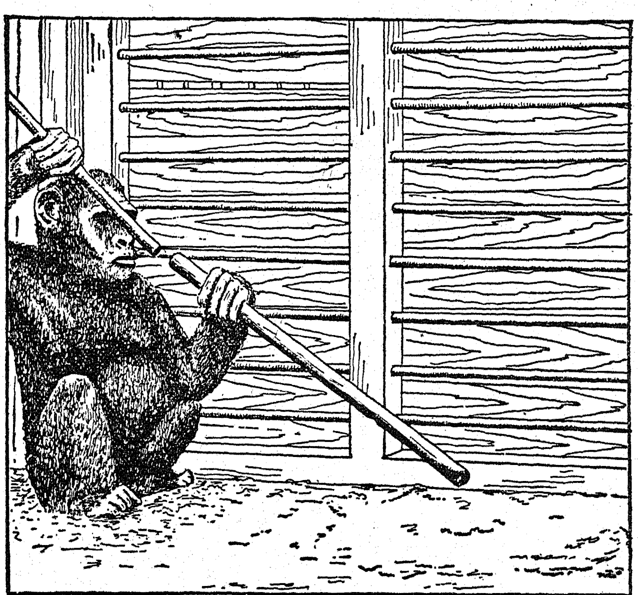


FIG. 72.—Chimpanzee fitting two sticks together to make a longer one which he can use to obtain food. (*After Köhler. From H. E. Garrett. Great experiments in psychology. New York: Appleton-Century,* 1930. *By permission of the publishers.*)

repetitions and blundering, the slow forging of synaptic connections by a long process of trial and error (and final success), the Gestaltist believes that our acquisitions are typically much more sudden and dramatic, that the trials are in their very essence purposive and directed, and that they culminate when successful in a sudden flash of insight. Even errors (which the trial-and-error view of things would call blind or random) are shown to be quite other than chance affairs, and though errors, they reveal an insightful process at work. Thus Koffka[1] writes:

[1] Koffka, K. *Growth of the mind,* p. 204. New York: Harcourt, 1924. Reprinted by permission of the publishers.

Along with these "stupid" errors certain other mistakes occurred which have a special significance in understanding the behavior involved. These other errors arise when one part of the principle of solution is correctly understood, while at the same time the problem involves some difficulty with which the animal is unable to cope. Thus, for instance, in order to increase the length of his stick, the animal would often seize two sticks and place them with the end of one touching the end of the other. This provided him with a longer stick, to be sure, but not with one he could use. It was this procedure that furnished the initial stage of Sultan's double-stick solution.[1]

Koffka continues:

To give still another example, the following behavior was observed in a "building" experiment. Chica found that with one box alone she could not attain the goal, no matter how high she jumped from it. Suddenly she grasped the box with both hands and, pressing it with great force against the wall of the room, lifted it to the height of her head in the direction of the goal which hung above. If only the box had remained stuck to the wall her problem would have been solved; for then she might easily have climbed upon it and reached the goal. . . . Good errors of this kind certainly cannot be explained by chance; because the acts we have called "good" errors do not appear in arbitrary situations, but only under conditions where they signify something "good," that is, where they actually bring the animal somehow nearer its goal.[2]

Where the physiological-mechanistic account of the learning process directs attention to physical stimuli and to the random character of the movements which those stimuli initiate, the Gestaltist is interested in what the animal is about. He views the changes in the animal's conduct as *transformations in perception*, involving a progressively deepening insight, rather than as a regrouping of reflexes automatically enforced by impinging stimuli.

Consider the following example:

A chimpanzee is shown a banana placed outside his cage just beyond his reach. Inside the cage is a stick with the aid of which the fruit can be secured. The ape in question has never previously been observed to

[1] In this experiment a hungry ape was offered bananas lying outside his cage and beyond his reach. Two sticks lying within the cage would, if fitted together, form a tool with which the bananas could be raked in. The single-stick solution, in this case inadequate in view of the distance of the objective, had been solved earlier.

[2] *Ibid.* Reprinted by permission of the publishers.

employ a stick as a "tool" and does not now perceive any possible connection between himself and the fruit via the stick. Instead, he reaches

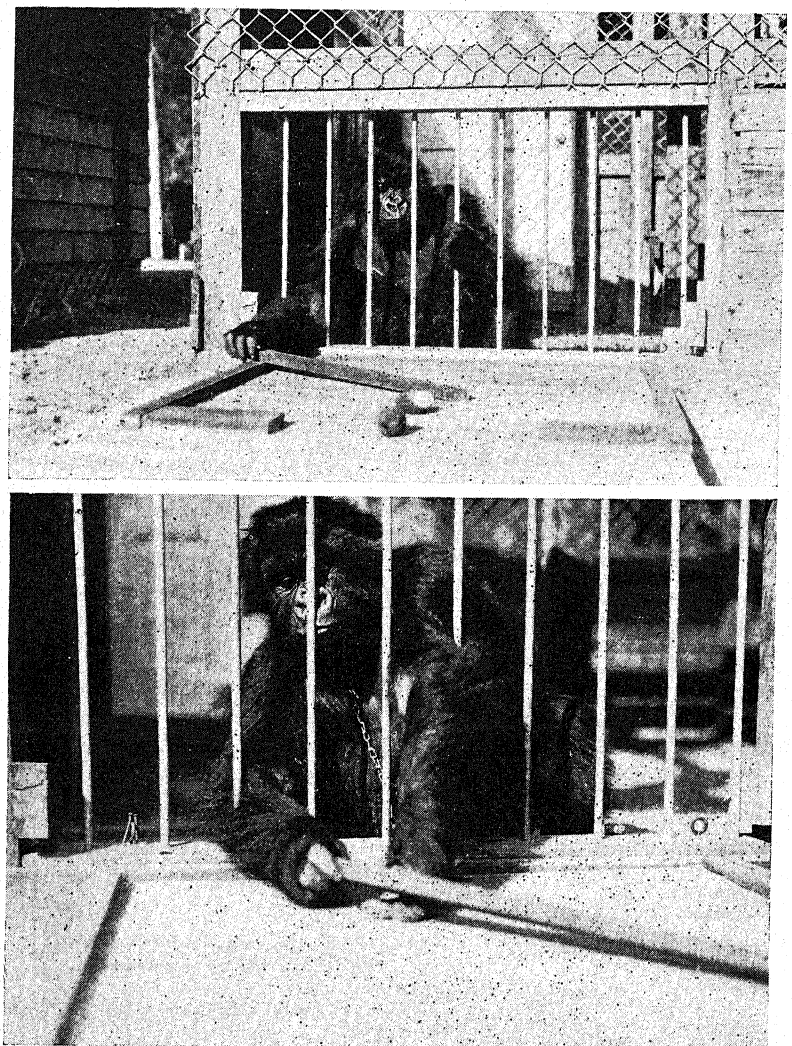


FIG. 73.—Gorilla using a stick as a tool. (*From R. M. Yerkes. The mind of a gorilla. Genet. Psychol. Monogr.*, 1927, 2, *No.* 1, *p.* 50. *By permission of the publishers.*)

vainly through the bars of the cage, and then busies himself otherwise; returning, however, again and again to the desired fruit, and repeating

his futile efforts. If the stick itself becomes an objective, he seizes it and plays with it without any observable reference to the fruit. But if, perchance, the stick and fruit fall together in the line of his regard, the situation is suddenly altered; for the stick is at once seized and correctly used in securing the fruit. This transformation of the situation is not only sudden but lasting. The animal learns in one successful trial to employ a stick in order to secure a desired object which lies beyond his reach. And with this transformation comes learning.[1]

Neither the concept of conditioning nor the trial-and-error view of learning has prepared us for such a sudden "transformation." The establishment and the extinction of the conditioned reaction (at least as conventionally described) are gradual processes. If one were to plot the results in the form of a learning curve, the line connecting the points which represent number of drops of saliva secreted at each trial would be a gradually sloping one, with minor irregularities (recessions) but with no sudden and permanent drops and rises. A similar statement would hold for the typical trial-and-error curve, though here the irregularities are even more pronounced.

The Question of Fact.—Fact and interpretation are so closely interwoven in our accounts of learning that it is necessary to raise most precise questions. We can scarcely question the cases of sudden solution which the Gestaltist has brought forward, however. These are experimental facts. Again and again the performance curves of his subjects have shown these sudden and permanent drops. The questions we must face are, Are these curves typical? Do they reveal the essence of the learning process? What is their true significance? And, finally, we must account for the fact that the Gestaltist's subjects so frequently show them, while for the most part those of Pavlov and Thorndike do not.

In the first place, it is worth noting that sudden drops in the learning curve appear in some of the curves first presented by Thorndike,[2] and that these curves were commented upon by this investigator. These instances, exceptional in Thorndike's data, were explained as due to one of two conditions: either the "association" in question was a very "easy" one (and hence could be formed in a few repetitions—and in extreme cases in a single trial) or the acts in question were of the sort "likely to be well attended to" (where, for example,

[1] Quoted from Ogden's account of an experiment of Köhler. See Ogden, R. M. *Psychology and education*, pp. 250–251. New York: Harcourt, 1926. Reprinted by permission of the publishers.

[2] Thorndike, E. L. *Animal intelligence*. New York: Macmillan, 1911.

the act is "one which the cat makes definitely to get out"). Thus we are left with (*a*) attention-ensuring factors and (*b*) "ease of the association." This second item Thorndike reduced to a question of "simplicity and definiteness" of the act.

If we couple the observations of Thorndike and those of the Gestaltists we may formulate our own inclusive generalizations in some such fashion as follows:

1. No one form of the learning curve need be regarded as typical for all situations or all learners.

2. The gradual descent, with frequent regressions (*i.e.*, the typical trial-and-error curve), appears.
   - (*a*) with the novice, the child, the beginner, or
   - (*b*) when the mass of stimuli confronting the learner is too complex, confusing, or unfamiliar to permit a selective, integrating type of response, or
   - (*c*) where motivation (subjective factors of attention) is ambiguous, confusing, or of too low intensity.

3. The sudden and permanent drop, indicating "insight" (*i.e.*, "grasp" of problem, sudden "reorganization"), appears:
   - (*a*) with the more experienced, more mature, more highly developed and organized individual, or
   - (*b*) when the stimuli are either few in number or so related and grouped that "significant" items "stand out" (*i.e.*, get attention) and hence direct a selective and integrated type of response, or
   - (*c*) where motivation is definite, and previous experience is adequate for the present task.

In short, it would appear that the Gestalt formulation is most applicable to those situations where intelligent, purposive behavior is possible; that is to say, where the attention of the performer is directed sharply upon an objective, where his behavior equipment (repertoire of acts) permits an integrated type of reaction to the constellation of stimuli before him, and where conditions (both subjective and objective) permit the *relationship* between the objective and the presented means to dominate and direct behavior.[1]

[1] Another study of learning which antedates the work of the Gestalt school gives evidence supporting many of their contentions. Ruger presented human subjects with an assortment of mechanical puzzles and observed their blundering attempts to solve them. In 128 curves he found 328 pronounced drops, and in 70 per cent of these cases the subjects were aware of and able to report upon an insight into the nature of the problem. Some of the sudden improvements were quite inexplicable, chance affairs, and these—more often than not—were not repeated. Many of the "insights" were hit upon quite by chance, a few were achieved by more rational methods (analysis of possibilities, and purposive and systematic

This summary of the facts suggests an even broader generalization. As an organism develops, the stimuli which play upon it acquire values which replace (and transcend) their original (physical) properties. The situations become meaningful and these "meanings," rather than the physical attributes of the stimuli (intensity, duration, etc.) assume regulative dominance. Random behavior will, therefore, tend to appear less frequently as development progresses; but at any stage it is possible, and its appearance signifies that pressures exerted upon the individual transcend his powers of integration or synthesis.

These generalizations help us to see why different investigators are able to report such divergent results. A frightened animal in a complicated puzzle box, confronted with buttons, levers, pulleys, may be expected to show random behavior, and a gradually descending curve. Similarly, the very structure of the early mazes—apart from their complexity—permitted no view of the whole, no "grasp" of relations. The selective attention process was thus handicapped by the very nature of the stimuli. With the simpler and more familiar materials of the Gestaltist, the attempt to place all items in full view of the learner, and to enhance the attention-getting value of the relevant items and relationships, the sudden solutions (insights) appeared.

Implications of the Gestalt View of Learning.—There is much in the Gestalt view that commends it to one concerned with the practical problem of directing the learner. The Gestalt description suggests that an appropriate ordering of materials will eliminate tedious blundering, that the deadening routine of practice can be replaced by "flashes of insight," that a grasp of the materials is more important than many repetitions, etc. One could take a page from a recent work by Thorndike[1] to demonstrate this latter point. When learners are given ten repetitions of a list of 10 sentences such as,

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variation to eliminate one after another of these possibilities); but an accidental success wherein the subject was unaware of his method of solving the puzzle (*i.e.*, in which he failed to react to the significant relationships) did not ordinarily produce any permanent gain. This gives both a new view of the significance of the blundering and of the importance of that type of reaction which the Gestaltist has called insight. Ruger's observations are reported in Ruger, H. A. The psychology of efficiency. *Arch. Psychol.*, 1910, 2, No. 15.

[1] Thorndike, E. L. *Human learning*, p. 19. New York: Appleton-Century, 1931.

Norman Foster and his mother bought much,
Alice Hanson and her teacher came yesterday,

the "bonds" between such sequences as "much—Alice" (2.75 per cent correct) are found to be much lower than such bonds as "Norman-Foster (21.5 per cent correct). A phrase such as "Norman Foster and his mother" was found to revive the word "*bought*" in 81 per cent of the cases, whereas a phrase of similar length at the end of a sentence was able to initiate the word beyond the inter-sentence gap in but 2 per cent of the cases. If we look at the words as so many isolated physical units, each given an equal number of repetitions, and each sequence as impressing itself upon a plastic (and passive) receiving organism, we might expect each bond to be of equal strength. Obviously such a mechanical view does not fit the facts. It is not the physical stimulus—as a temporal series of discrete units—which regulates the "recording." On the contrary, it is the *organization* made by the subject which is of primary importance.

Thorndike, in the illustration just quoted, is pressing for recognition of the principle of *belongingness*. To the more eclectic-minded it is bound to seem that this belonging-together is the very fact which the Gestaltist stresses. When a perceptual field takes shape under the stress of motivation and undergoes rapid transformation so that a figure emerges from a background, so that relations between means-and-ends are observed, at that moment *insight* occurs. In such a process the mechanical factor of repetition is secondary. To be sure, repetitions are necessary for learning. Other things being equal, more repetitions mean more frequent opportunities for the figure (organization) to emerge. It is further possible that once it has emerged further repetitions will more firmly fixate the pattern; but it is clear that we are no longer dealing with a mechanically efficient factor, with the automatic erosion of synaptic bonds.

Summary.—The Gestalt theory has certain limitations, finally, which we need to keep clearly in mind:

1. The Gestalt conception is not an all-inclusive one. Not all learning is of the "insightful" type. The facts of conditioning are a sufficient remainder here. We may add, too, the fact that all of us form countless conditioned responses that are completely below the level of awareness. Not only do we fail to "grasp" the situations in which they function, but we are often unaware of their presence.

2. Insight is no transcendent force. Reorganization of behavior does not always take place. Our subject in the conditioning experiment, quoted earlier

(page 419), may be fully aware of the import of warning stimuli, and may know that "shock" and "no shock" will follow in regular order. The behavior of his eyelid reaction may totally fail to correspond to this knowledge.

3. Our present knowledge of physiology does not permit a satisfactory formulation of this process of sudden transformation. The shortcomings of our physiological knowledge do not, of course, in any way minimize the importance of the facts brought forward by the Gestalt psychologist. We need to face, however, this fact: the Gestalt formulation is far from complete.

4. At its worst the Gestalt formulation threatens to carry us back into a loose subjectivism. It is not enough to be able to explain the rapid spurts in learning by referring to the performer's insights and perceptions of relations. So long as we rest here we are doing little better than Wundt, who so cleverly introspected for his ants and cats, speculating upon the nature of their "associations." We need more specific analyses of the limiting conditions under which "organizations" occur. The more objectively these can be stated the sooner shall we be able to raise those experimental questions which will lead to fuller understanding of the entire process, both in terms of the stimulating situation and in terms of the underlying physiology of the process.

In concluding our brief summary of the Gestalt view of learning, two points may be selected for emphasis. In the first place, the Gestaltist is more likely to draw the explanatory principles out of the present dynamic situation than either the reflexologist or the follower of Thorndike. Thus, the Gestaltist stresses the fact that the ape had never used a stick as tool before. He had handled sticks, of course, but they had never been used as tools with which to rake in other desired objects. The *present perceptual situation*, compounded of the "felt want" (hunger, desire for the banana-out-of-reach, etc.) and the configurational grouping of objects (stick lying along the line of sight directed toward the objective), contains the relevant explanatory factors. In short, the organization of the field is not a perceptual pattern slowly built up by a process of conditioning, or trial and error, in which a mosaic is gradually assembled from reflex bits (with much fitting and rejection). On the contrary, it springs out of the dynamic present into full bloom.

Here the Gestaltist calls attention to the character of the performance itself. A dog, for example, is confined between two buildings and prevented from reaching an objective by the lattice fence across the end of the alleyway. He may zigzag back and forth, paw, scratch, and whine for a time—and then suddenly he turns and dashes away from the objective, back through the opening at the other end of the alleyway, around one of the buildings to the objective. His course is not a halting, jerky one with many recessions.

On the contrary, the arc of his pathway represents one smooth curve of action—as though its very beginning contained a preparation for the final steps of the chain. And that this can be no chance assembly—and its very form argues against chance—is further supported by the fact that it can be repeated again and again. Thus Köhler's ape, having succeeded in fitting his two sticks together, rakes in one banana after another, not pausing to eat them!

The second emphasis falls upon the nonmechanical character of the configuration. Having perceived the significant relations, the subject is at once able to react intelligently to the situation even though the physical character of the stimuli may be changed, even though different muscular coordinations are demanded. The chick that is taught to peck on the brighter of two cardboard squares (and to expect to be shooed away from the darker) will not continue to peck at a card of the same brightness when it is the darker member of a pair. The *relationship* and not the physical intensity of the stimulus is the governing cue. And on the side of the response, the actual sequence of muscular contractions is never mechanically fixed, but rather infinitely variable though constantly adapted to an end. Just as a bird builds a nest of a recognizable pattern out of varying materials and with a variable series of acts, our skilled acts (controlled as they are by relations) can never be understood as mechanical chains of muscular contractions. We shift our habits from standing to sitting postures, we change the size and speed of our handwriting, we shift from large to small keyboards, and although the musculature varies widely, the patterns found in our output seem to hold fairly constant.

It is clear that when one tries to conceive of the physiology of such a process the Gestaltist has posed a difficult problem. We cannot turn to "chained reflexes" nor to any conception which depends upon fixed neural pathways, synaptic junctions, etc. If we speak of "behavior patterns" at all, we must think of these patterns as highly fluid, capable of "expansion" and "constriction," of shift from one muscle group to another. Likewise the stimulus pattern becomes a configuration, a relationship, a figure-ground affair, rather than any fixed geometrical pattern or any fixed assembly of physical vibrations, intensities, etc. So difficult are the problems here presented that it is perhaps better to speak of the Gestalt problem, rather than of any solution which the Gestaltist proposes.

The Practical Consequences of Adopting a Theory of Learning

The practical man is often contemptuous of theory and the student often shares his attitude—feeling that there is altogether too much emphasis upon fine theoretical points, academic arguments. Why not dismiss the question as to which is the correct theory of learning and content ourselves with a recital of the *facts?*

Our answer to this is really twofold. In the first place, the facts turn out in most cases to be pretty ambiguous things. What the learner is actually doing and what the observer selects and interprets are so inextricably interwoven that the recital of the "bare facts" is the most difficult thing of all to achieve. A theory affords the conceptual framework within which the acts of the learner are placed; and an incorrect conceptual framework has the property of distorting, much as a pair of lenses would, all that transpires in the field under observation.

In the second place, what one does in a learning situation, one's method of procedure, one's arrangement of situations, will be greatly influenced by these theoretical questions. I know of no way of making the difference between the three views of learning more concrete than to ask the question, therefore, "How is one's management of a learning situation influenced by the adoption of a theory of the learning process?"

Consequences of Adopting the Trial-and-error Theory. 1. *Expect "Blundering."*—Instead of regarding blundering as a symptom of inefficient teaching, as the Gestaltist does, one need not be at all worried when blundering appears, for this is the way human beings and animals learn. *Insights* will emerge as the blunderer progresses from simpler associations to higher units. There is no royal road to these "higher units," save "try and try again."

In short, "we learn by doing." Rather than attempt to achieve insight by older methods (*e.g.*, by verbal or manual directions), the teacher should devote himself to arranging situations in which the learner has a chance to discover for himself what is significant.

In support of this emphasis there is the fact that actually putting the learner through the movement usually retards, rather than facilitates, the achievement of a desired coordination. If we were to give a child a block with the letter *A* grooved into its surface and were to instruct him to push his pencil through the groove (as a

means of teaching him the writing coordination), we should make poor progress. His dependence upon the sides of the grooves does not prepare him for the later free movement, for one thing; and in addition it is possible for him to achieve a successful tracing while at the same time making entirely false muscular contractions. Likewise, we do not teach a dog to get out of the puzzle box by putting his paw through the movements of turning the latch; not only does the "putting through" present a confusing mass of stimulation (tactual, visual, etc.), but the struggles of the animal (possibly a pulling *against* our movements) are in no sense similar to the movements he will later need when executing the movement under his own power. And lastly, dependence upon the guide is not the generally accepted goal of education. Like the insecure patient of the psychiatrist who is not yet freed from dependence upon her new mentor, the guided learner has acquired an adjustment to his teacher rather than to his problems. And if the learner must ultimately achieve the coordination under his own power, it seems reasonable to argue that the most direct route to this end is the most efficient method of learning.

This negative emphasis upon guidance has, of course, its limits. Mere blundering has little to recommend it. The blundering must be directed and methods that are wholly futile must be eliminated. But the teacher must exercise constant restraint in her supervision. The child who can work the mathematical problem when the paradigm is present or when the teacher's promptings keep him on the right track is still a long way from learning anything about mathematics as a tool for meeting a living situation.

2. *Motivation Is of First Importance.*—In fact, without that selective interest, without drive, learning is altogether impossible. In the first place, the drive "prods" the animal into action; in the second place, it introduces light and shadow into an otherwise indifferent field. Finally, since some version of the law of effect occupies a central position in the trial-and-error theory of selection, the motivating *tensions* and the *releases* (which are inextricably bound up with the tensions) which signalize success will be the teacher's primary concern.

Both punishment and reward may be used, but it seems to be the consensus of opinion among those who have experimented with the question that motivation is most successfully handled when it is kept in the positive phase. For one thing, drastic forms of punishment

tend to spread their effects over the whole learning situation and to induce, if not fear, at least a generalized inhibition and unresponsiveness. This danger grows greater as the tasks to be performed involve delicate discrimination and judgment. One must even be cautious in pointing out errors. (The writer, for example, can never spell the word *separate* without making a double reaction—is it sep-*e*-rate or sep-*a*-rate—simply because an overzealous grade teacher strove to impress upon her pupils the way *not* to spell the word.) The false response is effectively inhibited when the correct reaction is fixated, and emphasis should be on the latter process.

The fixating rewards are most effective when they afford *immediate* and *complete* release. A delay introduced between the successful performance and the releasing reward, as in feeding the animals who have successfully run a maze, has a measurable effect on their rate of learning the coordination. School children are similarly affected. It is equally true that, if one is interested in the transfer of what is learned to other situations, what is called an "intrinsic" type of reward is always better than one but remotely associated with the activity. The "prize" type of reward may secure the effort desired; but, unless satisfactions which are closely coupled with the activity itself are found, the likelihood of permanent effects (transferable to other situations where such extraneous prizes are wanting) is small. Force and cajolery can guarantee that the learner is "exposed" to his materials, and they can accomplish a certain amount of successful "animal training."[1]

The intelligent manipulation of tensions and releases is a difficult art and distinguishes the clever teacher from the "time-serving" routineer. But one aspect of the motivation problem can be mastered by all. The learner can always be kept informed of his progress, and promptly. How can the successful performance get in its "effect" unless there is some prompt record (visible or audible) of its occurrence? Moreover, the social factors of emulation and rivalry, the satisfactions inherent in the approval of the mentor, cannot operate unless this factor is utilized to its fullest.

A knowledge of results does more. It means that the striving of the learner is not "in the dark," that it becomes progressively more accurately directed. To be most efficient, therefore, the "knowledge

[1] Martin, Everett Dean, has an interesting discussion of the contrast between a "liberal education" and "animal training" in his *Meaning of a liberal education*, especially Chap. 2, pp. 23–45. New York: Norton, 1926.

of results" will present not merely a total score—some inclusive measure of efficiency—but will direct attention to the specific character of the gains registered, and to the field wherein further progress is needed.

There is a negative side to this stress upon motivation which is worth bringing out. In a sense it serves to correct the first emphasis—the willingness to accept blundering as a method of learning. For when the emphasis upon motivation is properly understood we can see that mere blundering, mere repetition, is not enough. Animal experiments show that the learner may wander around a maze for days without establishing patterns or linkages in his movements. It is the motivated repetition that yields the patterning, the chains of movement, the elimination of "false" responses. Activity and rote repetition are not enough. A learner is oriented toward an objective, driven by specific tensions, released from these same tensions (and "satisfied") when specific standards are achieved. Although there may be no learning without blundering, no fixation without trials, mere blundering and mere repetition are not enough.

Consequences of Adopting the Conditioned-response View.—At first glance the work upon conditioned responses appears to have but little bearing upon the everyday learning situation. There is a vast difference between the type of control exercised over Pavlov's harnessed subjects in a soundproof, lightproof laboratory, with stimuli presented at intervals regulated to the fraction of a second, and that which is possible in most human learning situations. Even though we may consider that Pavlov's method may afford those basic explanatory principles which we need to interpret other findings, it is difficult to see how we can utilize the method, say, in the schoolroom.[1]

The major interest in the conditioned-response studies has been upon the control of the learning situation, rather than upon the control of the learner. It is true that the conditioned salivary reflex could not be established efficiently in the animal that had just been fed. Pavlov also speaks of the need of having an alert animal, and

[1] For example, when Bernstein, Schlosberg, using momentary stimuli, report that associations are established in a "forward" order, and that the stimuli must be separated by an interval of at least 100 millisec. (and preferably 200), one sees little of pedagogical import, save perhaps the emphasis upon the order.

Schlosberg, H. A study of the conditioned patellar reflex. *J. exp. Psychol.*, 1928, 11, 468–494.

Bernstein, A. L. Temporal factors in the formation of conditioned eyelid reactions in human subjects. *J. gen. Psychol.*, 1934, 10, 173–197.

one, moreover, not disturbed and distracted by unusual visceral and organic factors (fright, sexual excitement, pain). But for the most part a pliable and passive experimental animal is taken for granted. Occasionally there has been some interest among the reflexologists in divergent types of subject. Pavlov comments upon the timid, fearful dog who performed so well in his experiments, and of the friendly, lively, and excitable one who so readily dropped asleep; but little has been made of these divergences in conditioned-reflex theory.

It is possible that the great instability of the conditioned reaction is due, in part at least, to this neglect of motivational factors and to the fact that the reflexologist is dealing with a narrow segment of activity instead of an integrated response of the entire organism. Recent investigations tend to reinforce this suspicion.

Among the emphases which emerge from the conditioned-reflex work, centered as it is upon control of the situation (external to the animal) and upon the arrangement of stimuli, the following may be noted:

1. *Repetition Alone Is Insufficient.*—It is the reinforced repetition that tends to fixate the bonds between associated reflexes. Repetition without reinforcement produces disintegration of the coordination. In this connection, the stress in training must be upon regularity, upon allowing no exceptions; for each deviation from the required procedure starts the disintegration process, and what is thus undone will have to be painstakingly built up again.

2. *Adapt the Training to the Situation in Which the Act Is to Function.*—The emphasis upon stability in the learning situation cuts in two directions. If the situation in which final performance is to function is itself a stable one, the recommendation clearly is that we should duplicate the final situation during training. Pavlov's student whose experimental animal gave conditioned reflexes when alone in the laboratory with the student but failed to respond as soon as Pavlov was called to witness the performance may be taken as a paradigm. When the final situation contains factors not found in the training situation we may be prepared for interference and habit breakdown.

Where the final situation is a variable one in which but a few relevant cues hold constant, the training must be a variable one. If these conditions are fulfilled, it will be possible to nullify the action of the irrelevant variables and to preserve the attachment between

the response and what is essential in the stimulating field. For most human activities the latter condition will hold, and therefore the pedagogical stress must be upon varying materials, illustrations, applications. The learner who has become efficient in one artificially stabilized set of conditions is still totally unprepared for the conditions in which he will have to use and apply his knowledge. Like the monkey who has learned to solve the one-latch problem box, and fails when two latches are presented, he has really failed to "get the hang of the thing."

3. *Where Discriminations Are Being Taught It Is Important to Proceed from Coarse to Fine.*—Pavlov, for example, found that he could establish discrimination between a circle and an ellipse when the two axes of the ellipse were in a 9:10 ratio, *provided* the training began with the coarser discrimination. There was complete failure when the more difficult relations were presented first.

Since the first tendency is to generalize (conditioned reactions spread to a wide group of similar stimuli), a discriminative grasp of relations calls for an exhaustion (or extinction) of such false "transfer." The boundary lines beyond which a principle does not apply are delimited by the painstaking process of extinguishing all the "extraterritorial" reactions. We cannot, however, begin with the boundary cases, for to do so is to invite premature inhibitions. The positive "flow" of behavior needs to be well established before the inhibition process begins. Thus the beginning of training should deal with black-white contrasts, with a distorted and simplified caricature of reality, with simple either-or choice. The balanced judgments, the qualified statements, represent the final stage. All these observations constitute, it is true, an elaboration of the obvious; but conditioned-reflex principles help to clarify the principles and to provide a theoretical guide for the teacher.

4. *Proceed from Concrete to Abstract.*—The difficulty in establishing the secondary and tertiary types of conditioned reflex, and the instability of these, once established, should serve as warning against premature introduction of abstract formulations. Not until the sensorimotor experiences are adequate, and reactions have become stable, is the learner ready for the abstract formulation. Thus the "meaning" should be familiar *before* the "symbol" is employed. Manipulation of objects must precede manipulation of numbers, descriptions. "Skull practice" is of value when the situations (and coordinations) have acquired a solid foundation.

All this serves to remind the teacher of the limited power of words, a reminder that is so often needed. And this emphasis is doubly important, of course, with the very young.

Not only in matters of discipline, in motivation, in character training, but in the presentation of instructional material, the use of the "object lesson," of the overt act, of the sample, of the visit to the locality, the observation of the process, is always to be recommended. Verbal formulas without adequate foundation are not only meaningless; they may disintegrate so rapidly that before experience can give substance to their shadowy form they will have evaporated, and all the time spent in their acquisition is lost.

Consequences of Adopting the Gestalt View of Learning. 1. *Blundering Is an Index of Improper Motivation.*—Like the trial-and-error view, we find the Gestalt conception stressing motivation—though with a new meaning; but unlike the trial-and-error view, we here find relatively little patience with blundering.

Since it is under the stress of a "felt want" that the perceptual fields take shape and configurational relationships emerge, motivation is of first importance. But motivation is here much more than "interest" or tension, more, in short, than some impelling stimulation (either internal or extraorganic). The motivation of the Gestaltist is more of the nature of an "expectancy," a goalward orientation, an awareness of all-but-complete relationships. Just as in proofreading we are prone to gloss over errors, to misread as correctly printed what is in fact an error, to "fill in" omitted letters, etc., so in all our perceptions there is a dynamic element, a stress-toward-completion. Like an all-but-complete familiar melody which insistently demands the concluding bars, the perceptual field of the learner contains a dynamic element—it is no conglomeration of isolated physical stimuli.

It is therefore imperative, if the teacher is to secure intelligent responses, to arrange materials so that the elements already in possession of her pupil can be mobilized, so that expectancy will be present and functioning, so that the pupil will confront these all-but-complete figures.

As a matter of fact, it is precisely when this perceptual-intellectual factor is neglected that the blundering type of learning appears. When there is no clear connection between act and goal, when the problem is poorly defined, when the parts are presented singly so that no "view of the whole" is possible, when the level of perform-

ance lies far beyond the pupil's equipment and experience, blundering occurs, and blundering is time consuming and in itself fruitless. With the best will in the world, with a general interest, or with tension (drive) sufficient to evoke repeated effort, there is nothing for the learner to do but flounder. Given a sufficiently long time during which these blunderings continue and a problem that is not altogether beyond the reach of those "chance" successes, the learner may stumble into an "insight." But with properly graded steps, and with adequate preparation of expectancy from stage to stage, this floundering can be reduced to a minimum. The presence of blundering is thus a barometer which measures (in inverse fashion) the intelligence of the teacher, and not merely that of the performer.

Here again there will be a negative emphasis upon drill, rote practice, etc. Especially since routine dulls interest, and since under this condition there is rapid loss of sight of objectives, it constitutes the opposite of an efficient technique.

2. *The Control of Configurational Factors Is Essential.*—With reference to the presentation of the material there are two important stresses.

In the first place, wherever it is possible one should use visual presentation, outlines, maps, charts, graphs. In short, those devices which permit a survey of the whole problem, which bring out configurational and relational factors—simultaneously presenting what otherwise would remain discrete—have an especial value. Sometimes artificial relationships are necessary for the beginner, caricatures, simplifications, exaggerations, and the visual tool is again most readily accessible.

We can illustrate the point by an example from Köhler. He found that the stick-banana problem was too difficult for his ape, as a first problem, when the stick lay at the back of the cage. Located here, the ape saw either the banana without the stick or the stick without the banana; and this rendered the fusion of the two into one action system a difficult task. But the solution could be achieved if the easier arrangement preceded. Like Pavlov's procedure with ellipse and circle, the performer must be drawn from the easy configuration to the more difficult one.

Again, some visual arrangements are more difficult than others. Although the ape could solve the problem when the stick at the back of the cage lay upon the ground, he could not solve it when the stick was a branch of a bush. In the latter situation it was "bound"

within the compact configuration of the bush and did not seem to be a "breakable," separable item. In the same way, the child who is learning colors finds it difficult to dissociate the film of color from the object itself, and he does not see the *blue* to which we point, but the dress itself. And in overcoming this tendency the teacher will have to discover the gaps which exist between his own perceptual tendencies and those of the pupil, for what appears to be clear and definite configuration to the experienced intelligence may not be so to the novice.

In the second place, the Gestaltist stresses the distinction between a "psychological" and a "logical" order of presentation. Since matter is composed of molecules and these in turn of atoms, electrons, and subelectronic particles, one might argue that the logical order of presenting the science of matter would be to begin with the smallest unit and to build from thence the whole elaborate framework of matter. Or, to take another instance, since the living cell constitutes the unit of living structures, all the biological sciences should begin with the study of the cell. However satisfying this might be to the expert, who can fully appreciate the significance of each step of the process (from cells to nerves, muscles, etc., organs, and finally the living organism), the Gestaltist insists that this is not pedagogically sound. The abstract conceptual units with which science works are really the last items to become knowledge. That is true historically and it is true with each learner.

If this criticism is true, then the modern textbook in psychology does not show that psychologists have the power of transferring the knowledge of which they speak into the practice of textbook writing. If the Gestaltist is correct, then in writing his book he should begin with the living totality and reach—last of all—the abstract formulations, the unitary processes. One textbook, at least, gives an illustration of a Gestaltist who has the courage of his convictions.[1]

A good illustration of the contrast in the two methods is afforded by different methods of teaching geography. When the writer first began this study in the grade school, he was invited to consider a map of the world, an orange, and the relation of the sun and the earth, etc. Now, while this illustrates one way of considering the "whole" before the parts are taken up, it represents the worst possible use of the method. For the *world*—especially as illustrated

[1] Wheeler, R. H. *The science of psychology.* New York: Crowell, 1929.

by the abstract symbols on the page of the text—had little meaning and was quite foreign to childish experience. Ball and orange had meaning, it is true, but nothing remotely connected with the problems of geography.

A much more meaningful method would begin with the world of the child, his own home, and the houses in the block; or with his schoolhouse, and surrounding town. These are "wholes," too, and meaningful ones, and from this base a significant geography could be taught. Map reading should evolve with the automobile trip, and a conception of distance out of actual distances traversed (and not from interstellar spaces).

Summary.—In examining the practical consequences which follow the adoption of the various theories we have, I think, shown that these theories are best viewed as different emphases rather than as mutually exclusive approaches to the problem of learning. Certain it is that no one view affords a complete and satisfactory theory of learning, and it is equally certain that our knowledge will advance through discoveries made by laboratory workers pursuing at one time or another all these emphases. To caricature the three emphases, we might describe the trial-and-error view as one which emphasizes the affective-volitional aspect of learning, the Gestalt view as one which emphasizes the perceptual-intellectual aspect, and the conditioned-reflex view as one which centers upon the stimulus, *i.e.*, upon controls of the external situation. Obviously all three aspects need consideration.

No one theory can be given a physiological translation that is altogether satisfactory. The trial-and-error view failed to account for the "stamping in" through the "effect," the conditioned reflex of Pavlov—which once promised a simple physiological formula—has grown so complicated that it has become little more than a formulation of procedures for conditioning, and the Gestaltist has not achieved a brain equivalent for his "fields" and "figure-ground" relationships that is within gunshot of modern physiological knowledge.

CHAPTER IX

PERCEPTION

The Subjective Factor

The world of reality may be approached from many angles. Like the blind men of the fable who went to "see" the elephant, our different approaches yield different "objects," and out of the conflict between our notions of reality arises the problem of perception. What is the relation between the external cue and our perceptions, and what laws govern their arousal?

The slightest reflection is sufficient to convince us that the subjective factor looms large; not only is there a conflict between our perceptions and those of our fellows, an object can change under our very eyes. We who dreamily listen to a melody, say the "Moonlight Sonata," hear it as a vague background to the overtones of imagery with which we are preoccupied. But if our musical interest is aroused, the object changes to a melodic figure, or to rhythm, or to a style of performance. As our attention plays over the field our perceptions change; our shifts in attitude mobilize different segments of our experience and they organize the external reality into changing configurations.

This change in experience with a shift in attitude suggests that there are an almost infinite number of perceptions of any given stimulus field, as many as there are interested observers or as many as there are purposes among the perceivers. It is only in our naïve moments that we are able to think of ourselves as rather superior recording instruments, able to turn eye and ear upon an outer world of "objective" reality, properly photographing and registering what is there. With a little reflection we become aware of a subjective "distortion"; and in conversation with our friends we discover the fact and debate the truth of our differing perceptions.

Social Perceptions

The Shaping of Stereotypes.—Perhaps no other phase of our experience illustrates the importance of the subjective element in

our perceptions so well as the field of social perceptions. Here we "read into" the words, gestures, and expressions of others a wealth of complicated meanings, intentions, and motives. We perceive our fellows as intelligent or stupid, as hostile or friendly, and we act in accordance with these perceptions. We cast our ballots at election time for candidates and policies which we have perceived as upright, honest, wise. And we make all these perceptions on the basis of relatively slight cues, with much filling out and interpreting. The "signs of the times" are but slight and partial hints, as the many contradictory interpretations bear witness. The implications of the amendment to the constitution (if, indeed, we can be said to perceive—and not imagine—them) must be read into exceedingly meager data, and the things which are supposedly taught by the "lesson of history" are so many and various that one is almost inclined to agree with the writer who describes history as a "fable agreed upon."

Assuming, then, the most complete honesty possible, the social observer who has become self-critical admits that his cues are slender and often variable and confusing; and that the interpretations which make up so large a part of the total experience may well be the product of relatively personal and isolated experiences (in his own past). And to the extent that social observations are concerned with disputed points and arise from conflict situations where feelings run high, these added interpretations render conversation across the conflict barrier extremely difficult, for the factors of bias, personal interest, serve to warp perceptions in the direction of the individual's desires. Confident persons see the enemy camp as replete with liars; those with less decisive character bewail the subjectivity of the social world, and postpone action.

Most of us recognize the distortion and simplification of social reality involved in the cartoon. The "capitalist," Uncle Sam, the reformer, and the Bolshevik of our daily paper are all accepted as the fictions that they are. And yet many of us fail to grasp a similar inadequacy and distortion in many of the stereotypes[1] with which we approach a more concrete social reality. We pigeonhole and classify those we meet as Catholics, Sophomores, Jews, Democrats, Fascists, workers, Negroes—and in placing them in these categories

[1] Cf. Lippmann, Walter, discussion of "stereotypes" in his *Public opinion*, Part III. New York: Harcourt, 1922.

we endow them with a set of attributes which we have not observed on this particular occasion and, often enough, with attributes which no one may ever have measured. Our notion of the Catholic may be a stereotype built up in boyhood days when there were whispered conversations about the guns stored in the basement of the fortress-like church, of adolescent gossip about human conduct in monasteries, and of postadolescent gossip at the Chamber of Commerce about business dealings with the Catholics (similarly distorted by similar childhood fantasies, no doubt, but serving to convince us of the objectivity of our judgment, nevertheless). Perhaps we have never had a dozen words with priest, or Bolshevik, but we have, nevertheless, rather complete stereotypes; and with this reaction equipment to furnish the "filling out" we go forth to discover—not what is "out there" among our cues—but what we project out there.

Born at a certain time and place, in a certain milieu, members of a certain social class, we receive as a part of our heritage, a set of cartoons of social reality. The traditions of family, and gang, and social set, seep into our mental make-up. Our very civilization may be founded upon lies (as Robert Briffault asserts); but we shall have a difficult time in detecting the fact, for when lies are believed supporting evidence has a way of turning up. And the cracker-barrel philosopher is not the only one who should preface his remarks with, "I see by the papers." To such an extent do we view the world around us through the eyes of others, through the mists of stereotype and cartoon, through mythical and biased residues which we have received through word and picture, that we do "see by the papers" instead of with our own vision. In fact, our vision is unable, often, to correct the distortion. This is especially true of all those distant and complicated events where we all have to rely upon indirect evidence. Our stereotypes, here, constitute the whole of social reality—as we are able to meet it. We think with them, and can correct them only in terms of other stereotypes.

Thus, as Lippmann has so vividly pointed out, our morning newspaper is much more than a folded sheet of newsprint still smelling of ink. It provides us with a world of stereotypes in which we live. So, too, our tickets to the movies, or the play, purchase more than a few hours of amusement, for here the confusing social world about us is given a simplified shape and pattern, easily grasped, and it is out of such an equipment of "shapes" or "types" that our social perceptions (of the "real" world) are manufactured.

The Perceptions of Persons, Traits.—Although the systems of physiognomy and phrenology have long since been abandoned, many of us believe that we can perceive personality traits rather directly and immediately. We feel that the photograph of the stranger bespeaks intelligence, pride, defiance, craftiness, etc. Occasionally we are shocked because the photograph of the convicted criminal shows such a fine face, such intelligence, and in our surprise we betray the fact that certain expectations have been violated.

It is rather difficult to say what the basis of such impressions really is. Probably there are few general cues, and many that depend upon our individual experiences with similarly formed features. It should be apparent at once, however, that the superficial features which are visible to an outside observer can have little connection with those internal structures which mediate habits, and when we remember that in judging personality we are really anticipating a set

TABLE 12.—PERCENTAGE OF CORRECT JUDGMENTS OF RELATIVE INTELLIGENCE PORTRAYED BY PAIRS OF PHOTOGRAPHS

Pair	Per cent correct	Per cent wrong	Number of judges
2 men	46	54	84
2 women	49	51	84
Man and woman	50	50	62
Man and woman	56	44	62
Average	50.2	49.8	

of habit responses there can scarcely be any logical reason why we should expect to read personality from superficial and temporary impressions of an individual, least of all from a photograph.

Numerous attempts to measure the accuracy of such impressions have been made, and the results have been disappointing (*i.e.*, to those whose naïve expectations were violated). Physicians, psychologists, students, teachers were asked by Pintner to rate the photographs of twelve children, ranging in intelligence (as measured by the Yerkes-Bridges scale) from very bright to feeble-minded. The correlations, while differing from judge to judge, showed that the group as a whole yielded little more than might have been expected had the judges studied the backs of the photographs. Laird and Remmers,[1] who actually employed this latter method as a

[1] Laird, D. A., and Remmers, H. A study of estimates of intelligence from photographs. *J. exp. Psychol.*, 1924, 7, 429–446.

control, found that the results for 376 judges gave similar "chance" results. In one phase of the experiment in which the task was somewhat simplified, and the judge was merely asked to compare the intelligence of two members of a pair, the chance character of the results is clearly brought out. The experimenters conclude that such estimations seem to be of purely chance accuracy, that the few "good" judges (*i.e.*, as defined in this study as denoted by high scores) may achieve low scores on a retest, that neither the age nor the intelligence of the judge seems to be a factor, and that groups of judges do not achieve any better scores than the individual judges working alone.

Another study, by Hollingworth, is even more disillusioning. In this case the judges, twelve expert employment or sales managers,

TABLE 13.[1]—ESTIMATES OF CANDIDATES' ABILITY BY SALES MANAGERS

Candidates	Sales managers											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
A	33	46	6	56	25	32	12	38	23	22	22	9
B	36	50	43	17	51	47	38	20	38	55	39	9
C	53	10	6	21	16	9	20	2	57	28	1	26
D	44	25	13	48	7	8	43	11	17	12	20	9
E	54	41	33	19	28	48	8	10	56	8	19	26
F	18	13	13	8	11	15	15	31	32	18	25	9

The Roman numerals indicate the sales managers; the letters on the left indicate the applicants; the numbers in the table indicate the ranks which the sales managers gave the candidates. The number 1 indicates a candidate was judged to be the best, while 57 means the poorest of the lot.

[1] The figures are quoted by Gates, A. I., *Elementary Psychology*, p. 402 (New York: Macmillan, 1925), from an article by H. L. Hollingworth in *Salesmanship*, December, 1916.

had direct access to those rated. The applicants were closeted with their judges for a personal interview, they were under observation as they worked at a two-hour test, and each stood up before an audience to announce his name and certain other facts. Moreover, the applicants were being examined for a particular type of work with which the judges were presumably familiar. Here the judges had access to attitudes, postures, and all the cues afforded by the moving subject, as well as his answers to questions. A glance at Table 13 shows such extreme variability in the judgments that this method, too, must be discarded.

Other experiments have shown that some uniformity and agreement among judges is possible without adding to the validity of the

method. That is, certain constant errors based upon certain superficial signs may creep in. The author is not aware of any study which systematically explores the relationship between the items in personal appearance and such judgments. Possibly there is no such relationship which would yield any marked uniformity in judgments. The great diversity in the various schemes of diagnosis from physiognomy would seem to suggest that the latter case is the true one.

It would seem, from the studies examined, that there is no system of "reading" personality. One perceives a person when one anticipates *the actions-to-come*, and a person's habitual ways of acting are revealed through continued association with him. There are no cues, apparently, short of such association which will provide an adequate basis for perceptions in this field.

Summary.—This cursory examination of the problem of social perceptions suggests two generalizations: (1) the matrix within which the individual develops provides him with "trends," attitudes, stereotypes, which form the basis of his later perceptions, and (2) it is difficult to conceive of any development, as life is now lived, which will not at the same time *distort* the individual's conception of reality. We may enlarge upon these points briefly.

Another way of phrasing the first generalization is to say that the forces which shape the individual also shape his perceptions, and thus the "reality" which he "sees" and within which he imagines his actions to take place. Perhaps this observation is too obvious to need belaboring. He who runs may see that where, as in modern Germany, a Fascist-controlled press acts as a distorting filter, a citizen's perceptions of activities of other nations—and his subsequent actions and adjustments to these perceptions—do not so much represent the achievement of an individual organism as they do a social (and international) situation. It is not the individual German who is "insane" to follow Nazi leadership. The insanity is rather a social illness. No amount of delving into the vagaries of the German's biological make-up, his constitutional predispositions, his glandular make-up, his racial endowment, will reveal the peculiar groundwork which explains his mental operations. The problem must be attacked at a different level of analysis.

The second generalization points to the inevitability of bias in all social perceptions. The "reality" which shapes is always a *segment*, a local manifestation. It is *our* family, *our* neighborhood, *our* class, which is immediate and pressing. And as surely as these

proximal situations have their dynamic aspects, local and particular (and conflicting) interests arise. The child's reaction to the authority he meets in the schoolroom will inevitably be colored by the authority he experiences in the home. The boy's relationship with his mother will inevitably color his attitude toward, and demands upon, feminine companionship in the years which follow. His suspicions, resentments, his loves, his habits of sharing (or of greed), go to make up a personality that is no mere static structure, but which is dynamic in its very essence, and his impulsions and aversions, his anxieties and his hates, will all emerge to give shape, individuality (and his own measure of distortion), to his perceptions.

On the face of it, both of these generalizations invite pessimism. They stress the difficulty of achieving objectivity in social judgments, or of discovering anything approximating truth in the social sphere. But it is only through the frank recognition of these limitations that any closer approximation to social intelligence is possible. It is this type of "conviction of sin" which must precede any solution to the personal and social problems which confront us all. If social science is still in its infancy, and if political intelligence is still low, may it not be because the need for more facts, the need for social measurement, and the need for a continuing education into the adult years have been slow to dawn? We need more facts, and until we receive them—suspended judgment; and we need to realize that as yet most of our social perceptions are "in the dark," subject to the distortion of special interests, narrow experience, and to realize that until these things are corrected we shall continue to "thob" instead of think, to "project" a distorted "reality" instead of perceiving the world we actually live in.

Perception of Space

Berkeley's Analysis of the Problem.—We are not only aware of the *presence* of objects, we are aware of a spatial order, of distance and direction, and of temporal sequence. The first systematic formulation of this problem, in anything approaching modern terms, was given by Berkeley in 1709. Whereas the ancient Greeks had looked upon the perception process as mainly one of reception—in some vague way thinking of "copies" of objects passing down the hollow sensory tubes to the ventricles where the anima received and inspected them—Berkeley attempted to show how the spatial characteristics of the object were built up out of experience.

We do not "see" distance, form, and size directly, he argued. They are suggested to us. The visual sensations, having been coupled frequently with touch, now suggest the latter, and it is this suggested meaning which fills out and completes the perception of an object. He pointed out that the "strains" of focusing and converging the eyes upon an object derive their meaning (and give us the spatial object) by means of the associated touch images which they arouse. Thus we might summarize the Berkeleian influence as follows: (1) perception is a habit, and (2) always involves the addition of memories to the presently given sensory experience, and (3) in the case of space perception we may consider touch as the nucleus around which the spatial structure is built. Out of reaching and touching, walking toward, etc., the visual cues come to possess a "derived" meaning.

The Experiments of Stratton.—An American investigator, G. M. Stratton, took up the problem raised by Berkeley's analysis. He was particularly interested in the problem presented by the fact that, although the retinal image of the visual field is always an inverted one, we always "see" the world as upright. According to Berkeley, this is merely a matter of habit (or, to be more exact, a matter of the association of sensations). Stratton proposed to seek experimental confirmation of this fact.

In his first experiment[1] Stratton covered one eye, placed over the other a lens system which would invert the visual field's image upon the retina. (Thus the retinal image was "upright.") He wore the lenses some 21½ hours during a three-day period, and kept his eyes carefully blindfolded during the remainder of the period. While his observations are mainly qualitative, they suggest some interesting speculations. In the beginning there was, of course, uncertainty, awkwardness, surprise collisions with objects, and much groping for objects which could be seen but not directly located. All the field appeared inverted even at the end of the experiment and, in some undefined sense, unreal. There was a suggestion, at the very end of his trial, that a longer period of practice might wholly accomplish the reversal. For example, the visual cues began to warn him of contact-to-come, and—as he reports it—his limbs began to feel in the place where the new visual perceptions reported them. But for the most part the field seemed out of harmony with the larger

[1] Stratton, G. M. Some preliminary experiments on vision. *Psychol. Rev.*, 1896, 3, 611–617.

whole outside (it was as though objects tumbled into their positions as they came into the lens field, for he visualized them in the old terms). "On removing the glasses on the third day," he writes, "there was no peculiar experience. Normal vision was restored instantaneously and without any disturbance in the natural appearance of objects."[1]

Perhaps the only really encouraging item, from the standpoint of the habit explanation, was his observation that on a few occasions, when completely absorbed in some task, he lost all awareness of the inversion. To give a better opportunity to observe the changes, and to permit the automatizing process to proceed further, Stratton repeated the experiment,[2] extending the training period over eight days (87 hr. of lens vision). His experiences, for the first and last days of training, include such observations as:

First Day.—The scene appears upside down. Head and body movements set the whole visual field to swinging, and the field seems to move more rapidly than the observer. Movements have to be cautiously worked out as in a mirror-drawing experiment. "In pouring some milk into a glass, I must by careful trial and correction bring the surface of the milk to the spout of the pitcher, and then see to it that the surface of the milk in the glass remained everywhere equally distant from the glass's rim."[3] The strain is very fatiguing. Some relief comes in "shutting out" all visual cues (*e.g.*, in writing he tried to picture the coming strokes in the old preexperimental terms). Objects are seen in isolation. He writes: "I sat for some time watching a blazing open fire, without seeing that one of the logs had rolled far out on the hearth and was filling the room with smoke. Not until I caught the odor of the smoke and cast about for the cause, did I notice what had occurred."[3] The part of the field not in view is represented in the old preexperimental terms, and in the case of the parts of the body this representation seemed to invade the field of sight, giving a weird sense of having arms and legs with a double position. False anticipations are common. Walking under a hanging lamp produces an anticipatory shrinking in the region of the chin and neck (*i.e.*, in the neighborhood of the place where it disappears from view).

[1] *Ibid.* Reprinted by permission of the publishers.

[2] Stratton, G. M. Vision without inversion of the retinal image. *Psychol. Rev.*, 1897, 4, No. 4, 341–360 and 463–481.

[3] *Ibid.* Reprinted by permission of the publishers.

Eighth Day.—While there has been marked improvement in all coordinations and the sense of inversion and distortion is frequently completely absent, the training is by no means complete. In the morning, for example, before donning the lenses, the old preexperimental representations were in force. Tactual stimuli on the right and left sides are felt and visually represented in the old visual positions, though when the two hands are spread before the observer within the visual field the contact is accepted as coming from the seen touch. Sometimes it seems to shift back and forth. There is still hesitancy in deciding which hand to put forth to grasp an object. Sounding objects within the field of vision are accepted without confusion, *i.e.*, the sound seems to come from the visual object. Out of the field of view the object is referred to the old system of representation. The just-made-movement (as in the case of tapping) and other suggestion factors alter localizations. The lips never seem in place. In carrying food to the mouth it seems to disappear between the line of sight and the new position of the legs, though contact with the lips instantly changes the impression. The subordination of remnants of the old system of representations and anticipations is most complete during active movement. When sitting passively in a rocker the old system often comes back. Rocking induces the new. There are frequent lapses into a state wherein the subject seems to view the scene from an inverted body.

On removing the lenses, Stratton observed "a strange familiarity," an immediate recognition of the scene as the old preexperimental one mixed with a certain "bewildering" element which continued for several hours. Although it was not so strong as to make the scene viewed seem upside down, objects seemed to sweep ahead of a moving glance, much as they had when he had first donned the lenses. There were numerous false movements, extension of the wrong hand, turning the wrong way to avoid an obstacle, lifting the foot before reaching a step, turning the head the wrong way to see a peripherally cued object, moving the head up when it should have gone down. The dizziness and depression in the upper abdominal region (which had also been present on the first day) returns. The floor, and in fact the whole visual field, seems to sway. False anticipations (*e.g.*, shown by the surprise in seeing hands enter the visual field from the old lower side) are fairly common.

Stratton felt that he had demonstrated clearly:

1. That our spatial perceptions are a matter of experience, training, and association. The inverted retinal image "means" an upright field because of the nonvisual experiences which have been associated with it.

2. Reeducation is clearly possible, although neither experiment succeeded in completing the new associations. The old representations continued in force to the very last, even after movements to localize presented stimuli had been fairly well retrained. This fact, coupled with the relatively rapid[1] return of the old habits once the lenses were removed, indicates that our total system of visual objects is a comparatively stable structure.

Ewert's Repetition of the Stratton Experiment.—More recently, with an improvement in both apparatus and techniques (double lenses, extended measurements), Ewert[2] repeated the Stratton experiment. Three subjects performed auditory, visual, and tactual localization experiments through a two-week training period. In Ewert's experiment some disturbance of visual-motor coordinations persisted for three days after the removal of the lenses. Among the disturbances which he noted were: giddiness and considerable organic disturbance, faulty eye-head coordinations, a general rocking and swimming effect of the whole visual field, difficulty in fixation and accommodation. He notes, particularly, that this latter difficulty disappeared when the head and visual object remained stationary. There were frequent false turns and righting movements.

On the whole, it is not surprising that there should be such a rapid return to the normal adjustment. There have been years of sensorimotor conditioning against which a few hours of training are pitted, training through which many of the postural habits (vestibular-kinesthetic-motor) persisted without change.

The presence of these motor disturbances presents convincing evidence that the new perceptions set up during the training period are much more than matters of "sensation" or cortical response. The "false starts," the faulty eye movements (fixation and accommodation), show that the new perceptions consist, in reality, in new orientation tendencies, in new movement patterns. The "distance" which Berkeley argued was suggested by the strains of convergence and accommodation is a postural orientation. The "association between vision and touch" is a visual-motor response, a preparation

[1] Although his results are not couched in quantitative terms, it is apparent from his report that some disturbance persisted for at least 18 hours.

[2] Ewert, P. H. A study of the effect of inverted retinal stimulation upon spatially coordinated behavior. *Genet. Psych. Monogr*, 1930, 7, Nos. 3 and 4.

to reach out and touch, an incipient movement, a preparatory posture. The "uprightness" of the visual field consists in those balancing coordinations and postures of the subject, cued by the stimulus to the eye. The fact that new visual-motor habits can be established simply bears witness to the ease of conditioning the responses of the human subject. But without the background of training in the actual movements the incipient movements involved in perceiving are not possible. Without the fumbling of faulty adjustments, the "checkup" and correction following failures, no improvement is noted.[1]

Retinal and Postural Factors in Localizing Movements.—Let us turn, for the moment, to the overt spatial adjustment, the movement of localization. In order to simplify the situation let us imagine our subject seated in a dark room, with one eye blindfolded, the other eye stimulated by a point of light. He is instructed to point toward the source of stimulation. We have eliminated all binocular features, we neglect the form of the stimulus, its size and intensity, and we ask merely for direction (neglecting distance). When we flash the point of light, the subject's eye and head turn in the direction of the source (the first localizing movement) and the hand is raised in pointing toward the source. In our experiment the pointing of the hand does not occur until the eye and head are turned toward the source. The retinal stimulus is therefore at the moment of pointing a foveal one, *i.e.*, the eye has been turned, in fixation, so that the source, the pupil, and the point of clearest vision on the retina are all in line. If a new stimulus follows, from a different locality, the same sequence follows, and the retinal cue is again a foveal one. It becomes apparent at once that the retina alone does not control such pointing movements. One must consider the pattern of stimulation arising from the kinesthetic receptors in the eye musculature, and beyond that, the neck, the shoulder girdle, the whole posture. In short, the hand will move from a supporting postural matrix.

The early attempts to explain this power to localize stimuli falling upon a receptor surface (*e.g.*, skin or retina) developed the concept of "local sign." The capacity to discriminate and localize demands, it was argued, that each point stimulated have some sign of locality in addition to mere qualities of intensity or extensity.

[1] Both Stratton and Ewert note that the reeducation takes place most rapidly where overt movements take place, though insisting (without supporting evidence) that movement is not absolutely necessary.

Coupled with this was the notion of a perceiving mind located in the brain and receiving this "thereness quality," and later issuing commands to the appropriate muscle groups involved in the localizing movements. Somewhat less animistic was the notion, which grew from the study of the spinal animal, asserting that each stimulus point had its appropriate motor expression and that it was the movement, reflexly attached to the stimulated point, which in reality furnished the "sign."[1]

Both theories involved the animistic notion of a perceiving mind hidden from the outer world within its brain prison awaiting reports from the outer world, for even in the motor view the movement was thought of as furnishing (via kinesthetic sensations) signs of position. And both theories neglected the easily observed fact that the same retinal stimulus calls out a variety of localization movements (as in the first situation where the fixation precedes movement) and that a variety of retinal cues may call out the same movement (as would be the case where different fixation points yield different retinal cues although the position of the flash and the localizing movement remain unchanged). Whether one insists upon retaining a perceiving mind or not, it is apparent that the perception arises from an

[1] The nativistic view suggested by the motor variant of the local-sign theory does not find confirmation in the reports of congenital cataract cases. Where the patients, blind from birth, are given their sight through the operative removal of the cataract a great deal of education is necessary before the eyes are ready to function. Thus one subject when shown a water bottle thought it might be a horse, another thought square figures were round, others reported that objects seemed to touch their eyes. There are a few cases on record where some visual capacity is present as soon as the bandages are removed, but it is not possible to ascertain how much vision had existed before nor in many cases how early the blindness had begun. The few clear-cut cases on the negative side are rather convincing.

Stratton, G. M. The spatial harmony of touch and sight. *Mind*, 1899, 24, 492–505.

Senden, M. V. *Raum- und Gestaltauffassung des operierten Blindgeborenen vor und nach der Operation*. Leipzig. Barth, 1932.

Lashley and Russell, in a recent study (Lashley, K. S., and Russell, J. T. The mechanism of vision. XI A preliminary test of innate organization. *J. genet. Psy.*, 1934, 45, 136–144), have made out an impressive case for the nativistic hypothesis (at least as it applies to their animal subjects). Rats reared in darkness to 100 days were tested in their ability to jump to a platform placed at different distances. It was found that the force of the jumps (experimentally measured) was proportional to the distance of the landing platform, and that this adjustment was almost as accurate as that of normally reared animals.

organic matrix to which none of the local-sign theories do justice. It turns out that the sign for a spatial perception, while indicating a quite precise locality, is itself a decidedly diffuse affair. It is characteristic, but not local.

In addition to indicating the direction of the flashing point, our one-eyed subject will be able to estimate its distance, although with one eye his appreciation will not be so very accurate. (The reader can easily demonstrate the relative inaccuracy of such localizations by closing one eye and bringing in the pointing hand from the edge of the field of vision. If he attempts to touch an object in the field—preferably one not held in the other hand since this, too, affords cues—he will discover that the single eye affords a very rough guide for localization.)

With monocular vision there is but one depth cue supplied directly by the eye itself. When a visual stimulus falls upon the retina there is an adjustment of the ciliary muscle which supports the lens so as to bring the stimulus into clear focus (see page 118, Fig. 37). From these ciliary adjustments, and within a range of 50 ft. (at which distance the strain of accommodation ceases), we receive cues which are interpreted as distance or depth. Experiments have shown that the blurred image, when the lens is out of focus, gives no cue as to whether the stimulus is too near or too far, but that once the accommodation process has come to rest (*i.e.*, when the image has cleared up) the impression of distance arises.

In addition to the retinal, ciliary, postural cues there are a number of characteristics of the field which suggest depth. The factors most frequently listed follow:

1. The apparent size of objects, the dimensions being known.
2. The color of an object being known, the apparent color gives a cue, since colors tend toward blue at a distance. Haziness (aerial perspective) is a similar cue.
3. Superposition, the obstruction of the distant object by intervening ones.
4. Shadows.
5. The intensity of the reflected light, as, for example, the distribution of reflected intensities on a spherical surface.
6. Perspective, as, for example, when the two rails of a track stretching out before us appear to converge at the horizon.
7. Position in the field. The base of the more distant telephone post intersects the horizontal plane at a higher position in the field.
8. Relative motion of objects, as when a mid-point is selected for fixation and the motion of the observer is accompanied by a similar motion of more distant points, and a contrariwise motion of all nearer points. The apparent rate of motion is also a factor.

9. Up to distances of 50 ft., where the strain of accommodation ceases, the kinesthetic impulses from the ciliary muscle contribute cues. The blurred image, when the lens is out of focus, gives no cue, but the strain of the accommodation process, which is itself automatic, provides the stimulus.[1]

It is easy, in presenting a list of cues of this sort, to convert the perception process into an elaborate type of judgment. This would, of course, falsify what actually takes place. The subject does not note the size of his retinal image, and then, comparing it with some other remembered standard, infer its depth in the field. The reverse is nearer the truth. Long before these monocular factors were known, depth was immediately recognized. The primitive artist who drew the distant figure of a man in the same dimensions as the near figure, placed the distant one higher in the field but was apparently unaware of the other factor. He may have been vaguely dissatisfied with his reproduction, but the analysis of his failure was a much slower process. We have learned to perceive depth immediately. The cues are found later, by analysis.

This list of cues should serve to remind us of two things, namely, that our perceptions which we take for granted are the result of an elaborate training process and that our perceptions may be sharp and clear and definite without our having any awareness of the factors which contribute to the total reaction. Just as we cannot possibly name the muscles involved in the relatively simple act of tying our shoes, so we are not aware—as we perceive—of the elements which contribute to the unitary process.

So we react to the speech of our friend ordinarily as a whole, being quite unaware of syllable strokes, lip and tongue movements, etc. As we listen in rapt attention we seem to be hearing meanings, not sounds or movements. In fact, when we are questioned shortly afterward, our report may fail to reveal any knowledge of the very cue which determined our reaction.

It should also serve to warn us against accepting too simple a form of the movement theory of the process. The process of perceiving is not equivalent to the process of reproducing. The primitive artist whose crude representation of ranks of warriors places one warrior above another, neglecting the different sizes which perspective demands, could nevertheless perceive the depth factor better than this would indicate. No doubt with bow and

[1] From Pillsbury, W. B. *Fundamentals of psychology*, p. 428. New York: Macmillan, 1934.

arrow he could demonstrate the fact by an adequate "localization." Thus we must insist that the possession of differential reactions for two differing situations does not mean that the items in which they differ are thereby discriminated. A large and very useful part of our education consists in training in this last type of discrimination. The physician has been trained to differentiate the sick from the well, and to locate the items of difference; the efficiency expert, to discriminate between efficient and nonefficient production methods—and more, to locate the source of the inefficiency.

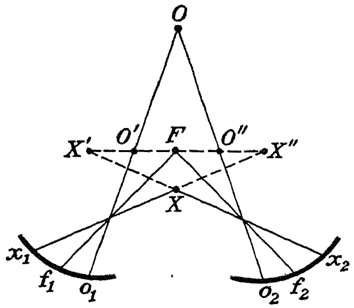


FIG. 74.—Diagram illustrating crossed and uncrossed double images. F, point of fixation; O, object lying behind the plane of fixation; X, object in front of the plane of fixation; O', O'' are the uncrossed images of O; X', X'', the crossed images of X (projected upon the plane of fixation); x_1, f_1, o_1, etc., retinal points corresponding to the object X, the point of fixation F, and the object O. (*From C. S. Myers. Textbook in Experimental Psychology, p.* 263. *New York: Longmans,* 1911. *By permission of the publishers.*)

It would appear that we have acquired the reactions to these cues without knowing it, and that they continue to operate even though we are quite unaware of their efficacy.

Binocular Cues.—Two additional cues are supplied when the two eyes are used together, the kinesthetic stimuli arising from the eye muscles as the eyes converge to bring the two foveas to bear upon the stimulus point (frequently referred to as the "strain of convergence") and the disparity in the retinal images. Of the two, the "double-image" factor is the more important, and yields greater accuracy, and operates up to greater distances. Whereas the accommodation factor is operative up to 50 feet, the convergence factor extends to 300 feet, and the double-image factor up to 2,500 feet.[1]

Double images provide another illustration of the point made above, namely, that we commonly react to cues of which we are

[1] The superiority of the retinal over the kinesthetic cues from eye muscles is easily demonstrated by a simple experiment. Fixate upon a point of light in an otherwise dark room and attempt to hold the eyes steady after the light has been extinguished. As the light is flashed on again one can see that the kinesthetic cues have not provided very accurate knowledge of eye position. Since this relatively coarse kinesthetic factor, according to our analysis, figures in all visual space localization, it should be apparent that our accurate movements within the visual field are subject to constant visual redirection and correction.

unaware. If one holds his two index fingers upright before him, one beyond the other, and fixates upon the nearer, as he closes first one eye and then the other the image of the farther finger is seen to jump back and forth. If we extend our observations and generalize, we may conclude that points in front of and beyond the fixation point are seen as double. Further, it will be seen

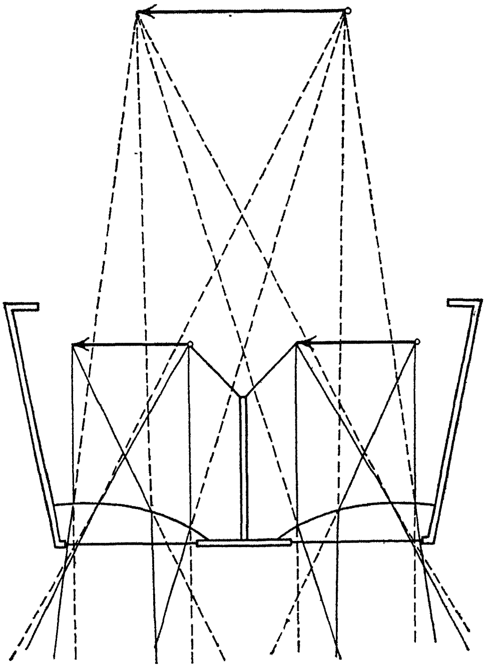


FIG. 75.—Stereoscope. Prisms turn the rays which enter the eyes so that the subject seems to be looking at a single object (arrow). The pictures placed in the stereoscope are taken with a double camera. Thus the view obtained by the left eye is identical with that which the eye would receive in looking at the object. Increasing the distance apart of the two cameras increases the disparity in the two views and exaggerates the depth factor. *(From E. B. Titchener. Experimental Psychology, p. 268. New York: Macmillan. 1901. By permission of the publishers.)*

that the degree of doubleness increases as the two fingers are separated. Again, if we look carefully at the double images we shall see that when we fixate the more distant finger and close, say, the right eye, the image of the near finger is seen on the right. If we fixate the near finger, the image of the remote one is seen on the left (when we close the right eye). The common way of expressing this is to say that the double images of the objects which lie beyond

the fixation point are uncrossed while those which lie on the side of the observer are crossed.

The stereoscope (Fig. 75) affords as illustration of the operation of these double images. Cards, upon which are mounted two pictures taken by a double camera so placed that the two lenses replace the two eyes, are placed before a lens system so that the subject is able to fuse the two pictures into one image. That is to say, the right eye receives the right camera picture seemingly from a position midway between the actual positions of the photographs. Fused with the left view, the two give a remarkably realistic impression of depth, such as no single photograph can give.

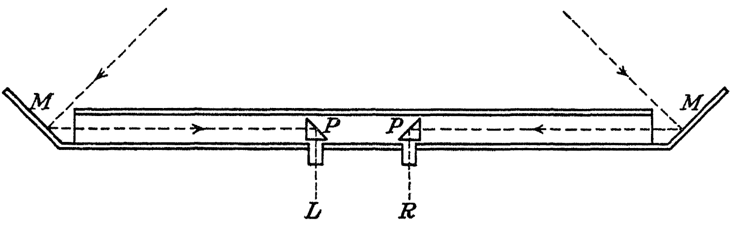


FIG. 76.—Teleostereoscope. A device which in effect increases the distance between the eyes of the observer, and in increasing the disparity between the two images enhances the effect of depth. (*From E. B. Titchener, op. cit., p. 272. By permission of the publishers.*)

The teleostereoscope (Fig. 76) and the pseudoscope are further extensions of the same principle, the former increasing the disparity in the images, the latter reversing them.

Perceiving the Location of a Tactual Stimulus.—Again let us illustrate the problem with an experiment. A subject is seated, blindfolded, with the volar surface of the left forearm exposed. In his right hand is placed a wooden stylus, with a rounded point, about 1 mm. across. A target point is selected by the experimenter, inked upon the surface of the forearm, and the subject is instructed, "When you are touched, point to the stimulated spot with the stylus in your right hand. Do not attempt to correct your localization once you have touched the skin surface." When a number of localizations have been recorded, something approximating the results shown in Fig. 77 (and in Table 14) will be found, with average errors lying between 5 and 22 mm.

It will be noted that in spite of the instructions we have not prevented the subject from correcting, for the errors have declined steadily throughout the trials. Apparently the first contact is

recognized as too far to the wrist, and the correction adjustment (though not overt) has provided a new postural matrix for the second localization. The numbers attached to the sample localizations presented in Fig. 77 show the process at work. If we free our subject from the restriction against immediate overt correction, the average for "first trials" (see Table 14) shows decided improvement. Still

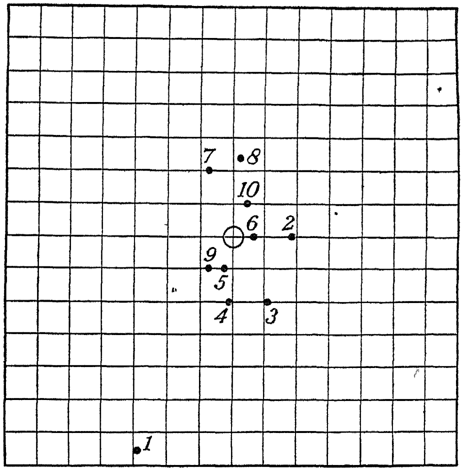


FIG. 77.—Series of localizations on the volar surface of the forearm. In this series the subject was instructed not to change his localization after the stylus had touched the skin surface. Note the correction which took place immediately after the first localization. In this first movement the subject seems to be "getting the range" of the surface. Once this coordination between members is established the errors fall within a narrow range. The lines represent distances of 5 mm. The circle represents the point repeatedly stimulated by the experimenter. Localization movements are numbered in the order of elicitation. (*From L. E. Cole. Localization of tactual space. Genet. Psychol. Monogr.*, 1929, 5, *No.* 5, *p.* 377. *By permission of the publishers.*)

more striking are the results obtained if we prevent the subject from making any contact with his skin surface by inserting a glass plate just above the forearm, so that all his movements terminate upon the plate. Since the glass plate yields no basis for correction, we should get results comparable to those of the very first members of our first series. That this is the case is shown in Table 14 (glass-plate instruction).

"Local Sign" and Postural Matrix.—As in the case of visual localization we need to think of the localization process as more than a process guided by an initiating "local sign." The localizing movement springs from a matrix of which the target surface stimula-

tion is but a part. The posture of the whole target limb furnishes as important cues as the tactual stimulus itself, for with each resting position of the arm the localizing member will have to make corresponding adaptations. As a matter of fact, if the experimenter moves the subject's arm while the latter is passive and relaxed, the

TABLE 14.—LOCALIZATION ERRORS UNDER DIFFERENT INSTRUCTIONS (VOLAR SURFACE OF FOREARM, L.) (In millimeters)

Instruction	Trials									
	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Ninth	Tenth
Do not correct once the stylus touches the surface (70 trials)	21.9	15.9	14.1	10.0	10.9	8.6	7.9	6.0	6 4	5 0
You may correct your localizations where possible (60 trials)	10.2	7.8	8.2	10.3	9.8	10.7	11.8	10.7	9 2	9.0
Make your localizations on the glass plate placing the point of your stylus as near the stimulated point as you can (420 trials)	20 5	24.3	28.8	29.8	27.0	30.3	25.5	27.0	24.3	24 8

The stimuli were presented in series of 10. Each of the figures under the first instruction represents averages for seven localizations, those under the second instruction averages for six, and those under the third method averages for forty-two.

initial localizing movements may miss the arm altogether. Furthermore, the change in results when the correction phase is eliminated from the localization process shows that accurate localization is a two-phase process containing first a coarse adjustment and then a fine one. According to the figures just presented, this coarse adjustment brings the localizing point, on the average, within a 20 mm. radius of the stimulated point, while the second phase reduces the error to from 5 to 10 mm.

The conventional explanation of this correction phase has been in terms of consciousness. Localization has been described as a "search for a sensation of the same local sign as the original sensation" and accurate localization has been attributed to the ability to hold an exact image of the first sensation in consciousness. The fine adjustment (*i.e.*, the correction phases) is thus viewed as a comparison between two sensations. It should be noted at once that when the correction phase is eliminated (as in the glass-plate method) the image persisting in consciousness is utterly incapable of guiding the movement to its accurate terminus. The correction phase arises, moreover, as soon as the second tactual stimulus occurs. Introspectively viewed, it appears as a "direction and distance," and logically we must insist that the correction phase, just as the first coarse adjustment, involves the whole matrix of posture. If the elbow of the target limb has been bent, the direction of the correction movement will differ from that which occurs when the target limb is held out straight; the identical wristward error is made in each case. That there is something held or stored and that there is more in the perception than is betrayed in the first phase of the localization movement must be granted.[1] The cortex, or consciousness, or local signs, or images, do not seem adequately to cover the case, for none of these are directive and none includes the postural matrix which a moment's consideration of the facts convinces us must be there.

The results which appear when the subject has knowledge of his results but is not allowed to correct at once (see Fig. 77 and Table 14, first method, page 460), show that it is possible to set up a corrected posture which bears within it the correction phase. Under these conditions the subsequent single-phase localizations are just as accurate as the two-phase process. Within two or three adjustments the postural matrix has become so accurately adjusted that the hand moves directly to the confines of the 5 to 10-mm. circle within which discriminations are not possible. One can easily demonstrate this process by closing one's eyes and striking repeatedly at the tip of the index finger with a pencil held in the other hand. The first two or three strokes may be wide of the mark, but

[1] This does not vitiate the movement theory of perception. There is more "held" than can be made explicit either in consciousness or in movement; for example, the glass-plate subject is wholly "at a loss" and can neither verbalize his error nor execute a correction movement.

very speedily an adjustment will be set up which permits one to strike the finger tip each time. If, however, the target finger tip is shifted to a new position, the fine adjustment will have to be set up again.

Verbal Report and Localization Movement.—Again, if another person stimulates us (when we are blindfolded), it will be seen that for certain areas we have a "verbal report" that is in one sense more accurate than any localization movement. We can respond, "That is the tip of the fourth finger," although we cannot move immediately and accurately to touch it without first setting up the "fine adjustment." This might be said to amount to a correction scheme or formula which we have ready to apply as soon as our localizing stylus falls upon the area, although we are not able to point accurately to the area. It is like being able to recall the position of an object in a bureau drawer although we are unable to point accurately to the bureau's location (in another room, for example). As soon as we enter the room, however, our formula unwinds and we move directly to the object. Or, to take another illustration, it is like being able to tell the exact measurement of a machine part to the thousandth of an inch without being able to produce, immediately, any such accurate response. With the proper tools and measuring instruments the machinist can turn out the part, for his verbal formula serves to symbolize a set of mechanical skills and measuring techniques. Just as the thousandth of an inch is below the visual threshold (or the tactual and kinesthetic, for that matter) and has to be pulled above the threshold by calipers and other instruments which convert the dimensions to a coarser visual scale, so the touched finger tip arouses a verbal formula which has a kind of accuracy greater than our first adjustments. Whether the tip is "localized"[1] is another matter.

Receptor Surface and Accuracy of Adjustment.—The "glass-plate" variant of the localization experiment serves to emphasize the role of the various elements in the process. On the palmar surface of the finger tip a blindfolded subject can discriminate between two touch stimuli separated by less than 2 mm. Within this very

[1] Under the conditions of the experiment it becomes correct to say that we perceive position more accurately than we can localize *if* perceiving position means naming the finger tip and visualizing it within a scheme of relations and *if* localizing means moving or preparing to move to the target. If, however, the two phases of localizing are recognized, there is seen to be no disparity between our perceptions and our preparations to respond.

sensitive area he can make extremely accurate correction adjustments and can report upon the distance and direction of a second point which is to be compared with a standard finger-tip contact. And all this is possible within the 2 mm. area in spite of the fact that the accuracy of locating the area as a whole is no greater than the accuracy for coarser areas, such as those of the forearm (see

TABLE 15.—LOCALIZATION ERRORS ON VARIOUS BODY SURFACES WHEN LOCALIZATIONS ARE MADE WITH AND WITHOUT KNOWLEDGE OF RESULTS

Body surface	Method of localization	
	Glass plate interposed between localizing stylus and skin surface. No correction possible (errors in millimeters)	Weber's second method. Stylus touches surface and subject permitted to correct (errors in millimeters)
Volar forearm, L...	27.4 (240)[1]	12.2 (240)
Dorsal forearm, L.	25.8 (420)	10.2 (420)
Dorsal forearm, R..	24.2 (130)	7.5 (140)
Forehead........	20.8 (90)	3.1 (120)
Middle finger, R..	29.2 (60)	1.7 (60)
Middle finger, L	33.9 (70)	1.9 (90)
Knee, R.	33.8 (60)	5.0 (60)

[1] The parenthetical numbers indicate the numbers of trials which were averaged to obtain the figure.

Table 15). Thus one notes that, if the correction phase is removed, the sensitivity of the surface bears very little relation to localization accuracy. No matter how accurate our discriminations within an area, if the area itself is "lost" the localizations cannot be accurate. And the limiting factor in our first localizations is one of posture.

This is most clearly illustrated by the first localization adjustments made to retinal cues.[1] If a subject is seated before a target so that his localization movements occur out of sight (as when, for example, his task is one of thrusting a needle up through the target surface from beneath), it will be discovered that his first localizations will have an error of *ca.* 15 to 20 mm. Seeing his error he will correct, and within two or three localizations his adjustments will be consistently accurate. Without this correction phase, in spite of very

[1] According to Starling, the retina has a "power of discrimination . . . three thousand times as great as that of the most sensitive part of the skin."

accurate visual discrimination capacities his localization movements will continue to have an average error of from 15 to 20 mm.

The figures presented in Table 16 indicate the distance which two points applied to the skin must be separated in order to be perceived as two. They give us some notion of the limit of the finer adjustment phase of localization. Various explanations have been offered to account for the varying sensitivity of these surfaces, the most common asserting that the differences in accuracy are due to differences in nerve supply, that the lips and finger tips, for example, are richly supplied with arborizations of sensory fibers. Thus Pillsbury writes, "the accuracy of localization is greatest where the nerve endings are most numerous."[1]

TABLE 16.[1]—TWO-POINT THRESHOLDS

	Millimeters
Tip of tongue	1
Tip of finger (palmar surface)	2
Lips (outer surface)	5
Tip of nose	7
Tip of finger (dorsal section)	7
Lips (inner surface)	20
Back of hand	32
Forearm, leg, and sacrum	40
Sternum	45
Spine	54
Arm and thigh (middle of back)	68

[1] Myers, C. S. *A textbook of experimental psychology*, Part I, p. 218. New York: Longmans, 1911. Reprinted by permission of the publisher.

According to Vierordt, the accuracy depends upon the flexibility and motility of the part. It should be noted that unpracticed areas (*e.g.*, the back) are of low discrimination accuracy. It is entirely possible that all three factors—innervation, motility, and practice—are involved. The first two would set an upper limit of capacity for a given surface, the last would determine the extent to which the capacity is developed. Experimental attempts to increase the accuracy of the *localization* process have not proved successful.[2]

[1] Pillsbury, W. B. *Fundamentals of psychology*, p. 414. New York: Macmillan. 1934.

[2] A recently reported observation of Purdy (Purdy, D. M., Tactual space perception in translocated tissue. *J. gen. Psychol.*, 1934, 10, 227–229) provides striking evidence of a similar character. In Purdy's subject, the terminal phalanx of the middle finger of the left hand had been removed as the result of an accident, and a residual patch of volar skin placed over the stump and

It is entirely possible that the few thousand trials to which experimental attempts have been limited have been insufficient, or that the methods of training have been at fault. The *two-point thresholds* indicated in Table 16 are easily lowered by training. In this case, wherein the subject is trained to discriminate between one- and two-point contacts, he seems to be learning to discriminate between tactual patterns, since a punctiform stimulus really depresses an appreciable area of the skin surface. As the compass bearing the two points is opened, first a circular, then an oval, then a dumbbell-shaped area, then two separated areas of skin are depressed. At first the oval and dumbbell-shaped areas will be reported as one contact. Later the subject reports two points. Thus, the change in the threshold would be attributed to the development of discrimination habits, in response to the various patterns of excitation.

Tactual Perceptions and Localizing Movements.—As in the visual perception problem, the cue for the response is seen to be more than the stimulation of a touch receptor. The "sign of locality" is not a local affair at all, but involves muscles, tendons, joints, postures. For each position of a stimulated finger tip (*e.g.*, the hand is held close to the trunk or is fully extended) a postural matrix provides a mass of stimulation which serves to direct the exploring hand toward the stimulated surface.

Evidence from Pathology.—But, we may ask, is it not possible to "perceive" the spot stimulated without making the exploration? And does not the very fact of a correction phase in the localization process point to the conclusion that it is the perception which guides the movement, and corrects it, rather than that the perception is a movement process itself? In short, is there any reason for our identifying our spatial perceptions and our localizing movements?

Henry Head, in his two-volume *Studies in neurology*, has a number of pathological cases which raise a similar question. In studying the effects of various lesions Head was able to show that the different sensory functions of the skin are affected independently. Thus a subject may have unimpaired sensitivity to touch (faint pressures)

stitched to the dorsal side of the second phalanx. Ten years after the operation the subject continued to give the old localization. In contradiction to these findings, and to the results of other experimenters, the recent study of Franz and Eaton (Franz, S. I., and Eaton, A. G. The possibility of training in tactile space perception. *Publ. Univ. California, Los Angeles, Educ. Philos. Psychol.*, 1933, 1, 91–98) yielded positive evidence of improvement with practice.

but be unable to discriminate one point from two. Or, as he notes in the following illustrative case, the subject may lose all sense of position of the limb, but be able to locate (by naming) points stimulated with normal accuracy.

In J. Y. (Case 10), who had entirely lost all knowledge of the position of his limbs, we performed the following experiments: his legs were extended in the bed, and he was allowed to see the position into which they had been placed. Then his eyes were closed and he was touched over the sole, instep, and just below the kneecap; in every instance his answers were correct, even though the touch was made with cotton wool. With his eyes still closed, the leg was moved into an entirely different position, and his answers were equally correct, although he was entirely ignorant that the leg had been moved, and believed it lay extended before him.

Directly he was asked to point out the spot that had been touched, the double nature of the groping test was apparent. In the attempt to find the spot he had named correctly, he beat the bed idly, entirely unable even to find his limb.[1]

In other cases Head used a slightly different method of measuring localizing ability. The member to be explored was photographed and the subject was asked to indicate on the photograph the location of the stimulus. Again, when the subject was totally unable to locate his left hand, he could localize on the photograph as accurately as when his normal hand was used.

We are thus reminded of what was emphasized in our own account (see page 462). There is more in the perception than is betrayed in the first phase of the localization movement. It should be clear, therefore, that if we are to follow behavioristic tradition and insist that our spatial perceptions are orientation tendencies[2] (which may or may not be completed in overt movements), we must, nevertheless, take care to account for such special cases as appear in the work of Head, and in the methods (cf. discussion of glass-plate method, page 459) where localization is made without knowledge of results. A subject can make a verbal report of his perception that is more accurate than the movements of localization he is able to make. That is, he can report that he has been touched on the tip of his little finger when he is unable to point to the little finger. That is to

[1] Head, Henry. *Studies in neurology*, Vol. II, p. 394. Oxford: The Clarendon Press, 1920. Reprinted by permission of the publishers.

[2] Peterson, Joseph. Local signs as orientation tendencies. *Psychol. Rev.*, 1926, 33, 218–236.

say, the perceptual adjustment is not fully revealed in a pointing reaction. In addition to such a preparation to point, there is a preparation to name, to explore a photograph of the surface, to correct the first gross approximating movement, to manipulate a particular kind of surface or member, etc. The complete perception, in short, involves all the habitual reactions to this type of stimulation. And while our techniques of measurement cannot reveal the exact locus and character of such implicit responses, the experimental facts give us no basis for discarding the behavioristic hypothesis. The facts *do* force us, however, to view the perceptual adjustment as a much more complicated one than an implicit pointing reaction.

A part of the difficulty presented by such cases as the one of Head is purely verbal. It would seem more correct to say that the spot stimulated is recognized than to say that its locality is perceived. It is recognized as a particular portion of the skin surface, although the skin surface is "lost." Just as we can locate a tone as above or below another tone, without being able to place either one on an absolute scale, we may locate a spot touched in relation to other touches without being able to give any of the spots an absolute position in space, or a position in reference to the localizing member.

Auditory Perception of Space.—Just as in the cases of touch and vision we pointed out that receptor surfaces are supported by a musculature, and that the "cues" for a localization adjustment are as much muscular as "sensory" (*i.e.*, from the skin or from the retina), so we should remind ourselves that in auditory perception the cues supplied by the inner ear furnish but a part of the stimulus pattern which initiates the turning of head and eyes, the pointing, etc. We should remember, too, that we are localizing sounding *objects* and not auditory sensations. When sensations (the unitary forms of consciousness, the supposed "atoms" of psychic substance) were considered the objects of the perception process, the senses of vision and hearing gave no end of trouble to the theoretician. Somehow the received sensations (probably occurring in the cortex—so the theory ran) had to be projected out into space. A stimulus-response psychology is excused from this problem, starting as it does with object and organism. The air disturbances (sound waves) thrown off by the sounding object strike the ears and set up auditory impulses which, when combined with the impulses from the postural matrix within which these receptors function, result in orientation adjustments. We might look upon the ears as a pair of sensitive

microphones, mounted upon the moving and pivoting column furnished by the bones and muscles of the neck and shoulders. Both the microphones and the supporting musculature supply the sensory stream for the localization adjustment.

Auditory Perception of Distance.—When we consider the changes in sound with an increase in distance, the most obvious factor is intensity. But, since the distant airplane motor and the buzzing of the near-by fly may provide the ear with approximately the same intensities, it will not be possible to localize a sound unless the nature of its source is known, and unless we have become familiar with its intensities at various distances (cued by other factors). Thus, if the sound source can be recognized, as, for example, through the particular pattern of frequencies that gives the source its characteristic quality, or timbre, and if long familiarity with the object has given the perceiver a set of spatial reactions for a scale of "intensities," the object will be placed at least roughly at its proper distance. It is also true that the quality of the sound varies with the distance, the weaker overtones dropping out.

At best auditory perception of distance is poor. With pure tones, with unfamiliar sources, it is very haphazard, indeed. As Banister suggests, "to perceive the distance of an unknown and unfamiliar source of sound a third ear would be necessary."[1] The convergence and double-image factors which help in vision are here lacking, and the factors which are left resemble those "subjective" factors which operate in monocular vision. Such, for example, would be the case when we assign the sounds of the passing motor to the street distance, its most probable position. (Or when we assign the locomotive to the distant tracks at the edge of town.)

Auditory Perception of Direction.—An experimental study of auditory perceptions, patterned after the work of Stratton on vision, was reported by Young[2] in 1928. Tubes running around the head connected the artificial pinna located on the left with the auditory meatus on the right, and a similar artificial outer ear on the opposite side with the opening to the left eardrum. Thus, the cues normally picked up by the right ear were received by the left, and vice versa. Thus, with eyes closed, a vehicle approaching from the left would

[1] Banister, H. Auditory phenomena and their stimulus correlations, in *Handbook of experimental psychology*. Worcester: Clark Univ. Press, 1934.

[2] Young, P. T. Auditory localization with acoustical transposition of the ears. *J. exp. Psychol.*, 1928, 11, 399–429.

seem to come from the right. Or, attempting to avoid a pedestrian approaching from the rear, whose footsteps seemed about to pass him on the right, he would step into the path of the pedestrian. This confusion persisted to the end of his experiment (lasting 18 days). As a demonstration of the acquired character of our spatial reactions to sound, the experiment was only partially successful. The subject, it is true, did not have as much reeducation as in the Stratton and Ewert experiments (here the pseudophone—as Young called his apparatus—was worn just an hour or two per day, with the exception of the last three days when it was worn continuously during the waking hours). The principal effect of the reeducation was noted when vision and hearing were both operating. At the beginning of the experiment there was a tendency to make "double" localizations, the true one visually cued and the false one produced by the transposed auditory cues. Even here the visual frequently dominated, and as the experiment progressed the auditory came to be more and more neglected.[1] To this extent reeducation was demonstrated.

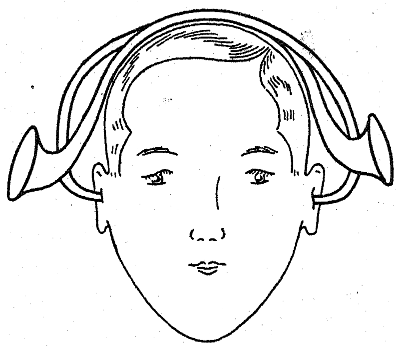


FIG. 78.—Young's pseudophone. The sound waves picked up by each trumpet are transferred by the tube to the opposite ear. (*After P. T. Young. Auditory localization with acoustical transposition of the ears. J. exp. Psychol.*, 1928, 11, *p.* 400. *By permission of the publishers.*)

The rough character of the auditory localizations revealed by experimental study, together with rather clear evidence of visual dominance, suggests that under normal conditions the auditory cues initiate a rough "groping" response of the eyes, comparable to the first (coarse) phase of the tactual localization. Once the eyes swing in the general direction of the sound source, visual cues operate to bring them to rest accurately fixated upon the object, and the further development of a localization reaction is under visual control.

[1] In the Stratton and Ewert experiments there was the same tendency to follow the visual cue, although in these experiments such a procedure resulted in false localizations. These facts seem to indicate that we regularly rely upon vision, and the large thresholds of error which are found under the most favorable conditions of auditory localization help to explain why this should be true.

Young's experiment clearly shows that the difference in the vibrations striking the two ears provides the principal cue for auditory localization of objects, since the transposition of the stimuli gives an illusory transposition of the object. Physically, the waves which arrive at the two ears may differ in *amplitude* (as when the source is nearer one ear), in *form* (as when the head provides a greater obstacle for the components of shorter wave length), in *phase* (except when the source is in the sagittal plane), or in the *time of arrival of the same*

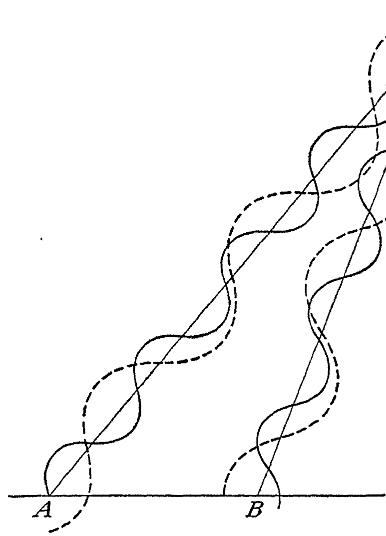


FIG. 79.—Two sine curves of different sizes so that the two are in different phases at *A* and *B*. (*From H. Banister. Auditory phenomena and their stimulus correlations. Handbook of Experimental Psychology, p.* 907. *Worcester: Clark University Press,* 1934. *By permission of the publishers.*)

portion of the wave. This last difference is not to be confused with the phase difference, for it does not vary with the frequency of the waves (as does the phase difference) (see Fig. 79).

As for the first factor, differences in amplitude (sound intensity), there are considerations both experimental and theoretical which minimize its importance. If important at all, it is clearly of greater significance for sound sources very near at hand, for when the sound comes from a source at considerable distance, the intensity differences would seem to be altogether too slight to be operative. Moreover, as the physicist points out, the head will not cast an appreciable sound shadow for the longer waves, and intensity differences would

operate only with the higher frequencies. Experimental studies in which the intensity and timbre of sound sources were held constant show that the apparent position of the source can be made to vary as the waves are made to arrive at one ear before the other. Other experiments show that very large changes in the intensity ratios do not alter the apparent position of the source.[1]

Evidence sometimes suggested as demonstrating the importance of intensity differences is of a purely negative character. Thus, when it is pointed out that sounds located in the median plane are frequently misplaced 180 degrees (as when front and back are confused) we should remember that this plane is not merely the locus of points which will stimulate the two ears with equal intensities, but the time and phase relationships are also equal.

The confusion between the front and back positions in the sagittal plane is much greater if pure tones are used, reaching figures close to pure chance in this case. If complex tones or noises are used as sources, accuracy improves, and may increase with practice. This fact suggests that changes in the quality of the sound, due to the action of the external ear as resonator (and as interfering shield for positions behind the head), may furnish cues. Experimental studies which control the source, varying timbre, support this hypothesis, for under these conditions the apparent position of the source changes.[2] Myers, who carried out such experiments, also found that placing short rubber tubes in the ears destroyed the capacity for localization, and attaching artificial flaps to the external ear created false localizations. One can observe the change in quality of a complex sound source by comparing the ticks of a watch placed in front of the head with those produced as the same watch is moved to a position behind the head. Myers points out that in addition to the resonator effect of the external ear, the obstruction to waves coming from the rear, the sound shadow cast by the head introduces changes in timbre. He writes:

> Inasmuch as the shadow effect of an obstacle increases with the shortness of the wave length of the sound, it follows that the sound shadow cast by the head must be different for the different overtones that are present in a given sound. That is to say, a laterally placed sound, reach-

[1] Banister, *op. cit.*

[2] Myers, C. S. The influence of timbre and loudness on the localization of sounds. *Proc. roy. Soc.*, 1914, B88, 267–284.

ing one side of the head, will be of different timbre from that reaching the other side through the air.[1]

The improvement of sagittal localizations with practice would seem to offer conclusive proof of the possibility of using qualitative differences, although the necessity of such practice would seem to indicate that ordinary experience does not provide us with the discriminative reactions. (Time, phase, and intensity are of course ruled out in the sagittal plane.) Myers reports that such practice has a greater effect with the complex tones and noises than with the relatively pure tone of the tuning fork, which should be expected if the hypothesis is true.

The experimental study of phase differences has produced conflicting results. Stewart[2] (1920) and Halverson[3] (1922) produce evidence in its favor. Wilson and Myers[4] (1908) were inclined to reduce the phase differences to intensity differences, arguing that bone conduction through the head would produce interference effects. Banister,[5] summarizing the experimental evidence, points out that the perceived direction "is not constant for a given phase difference. The displacement to one side depends also on the frequency, being less for high than for low frequencies, if the phase difference is constant. The whole hypothesis has recently been subject to very close scrutiny, which has not resulted in a finding in its favor."[5]

The fourth factor upon which experimental evidence is available, the difference of time between the arrival of the same sound wave at the two ears, seems most applicable to the interrupted sound source. That continuously sounding sources can be located suggests that other factors are also operating. Where clicks are supplied through headphones to the ears, and the time interval is controlled, the localization shifts regularly with changes in the intervals up to a maximum (fixed by the distance around the head). Beyond this point localizations become ambiguous.

[1] Myers, C. S. *A textbook of experimental psychology*, p. 276. New York: Longmans, 1911. Reprinted by permission of the publishers.

[2] Stewart, G. W. A suggestion towards a new hypothesis regarding localization of sound. *Brit. J. Psychol.*, 1920, 17, 142–153.

[3] Halverson, H. M. Binaural localization of tones as dependent upon differences of phase and intensity. *Amer. J. Psychol.*, 1922, 33, 178–212.

[4] Wilson, H. A., and Myers, C. S. The influence of binaural phase differences on the localization of sounds. *Brit. J. Psychol.*, 1908, 2, 363–385.

[5] Banister, *op. cit.*, p. 908. Reprinted by permission of the publishers.

Spatial Adjustments of the Blind.—The auditory cues which play such a subordinate role in the spatial reactions of the seeing person become of vital importance to the blind. And while the loss of sight does not alter the threshold of the blind subject for auditory cues (*i.e.*, the limit of sensitivity to faintest sounds), the enforced training does develop discrimination reactions to cues which the seeing person neglects. The sounds reflected from buildings, doorways, fences, come to have recognizable qualities. Where we occasionally note changes in sounds, as in entering an empty uncarpeted room, the blind person is reacting to such qualitative changes constantly. Thus, the blind person frequently shows an uncanny ability to avoid obstacles, to estimate the size of a room. According to William James:

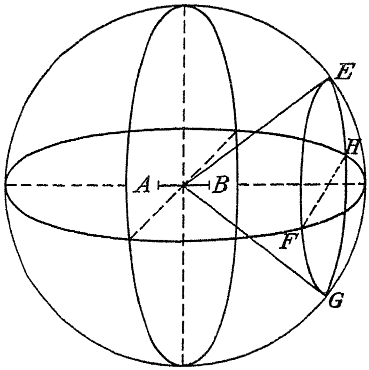


FIG. 80.—Diagram showing locus of equivalent stimuli. *A* and *B*, locations of the two ears. *E*, *F*, *G*, *H*, sources of stimulation producing equivalent differences at the two ears. (*From H. Banister, op. cit., p.* 906. *By permission of the publishers.*)

> On the prairies they feel the great openness; in the valleys they feel closed in; and one has told me that he thought few seeing people could enjoy the view from a mountaintop more than he.[1]

A case, reported by James, is quoted as saying:

> When passing along a street I can distinguish shops from private houses, and even point out the doors and windows, etc., and this whether the doors be shut or open. When a window consists of one entire sheet of glass, it is more difficult to discover than one composed of a number of small panes. . . . While walking with a friend in Forest Lane, Stratford, I said, pointing to a fence which separated the road from a field, "Those rails are not quite as high as my shoulder. . . ." When the lower part of a fence is brickwork, and the upper part rails, the fact can be detected, and the line where the two meet easily perceived. Irregularities in height, and projections and indentations in walls, can also be discovered.[1]

A similar case, described by James, demonstrated clearly that the cues were of an auditory character by stopping the ears with cotton

[1] From James, William. *Principles of psychology*, Vol. II, p. 204. New York: Holt, 1890. Reprinted by permission of the publishers.

and covering the orifice with putty. The subject under observation was of the opinion that his perceptions were quite independent of hearing, but the complete stoppage of the ears destroyed the perceptions. An experiment by the director of an asylum for the blind[1] makes the same point. Substituting felt slippers for the heavy shoes of the children who were being observed, he noted that they ran into obstacles which had been previously avoided under the guidance of their reflected footfalls.

Perception and Action

The implication of our discussion of the process of perceiving is clear: perception and action are intimately connected. In fact, we have been saying that behavioristically the organization and structure of the perceptual field is an organization of movements.

Genetically, this would mean that the "blooming, buzzing confusion" which constitutes the world of the child is resolved to an ordered structure as rapidly as his movements become organized to fit the configurations of stimuli. Like an adult dizzy from being whirled, the world must swim and pitch before the eyes of the neonate, streaking and rotating; for even when he is held in his mother's arms the muscles of his legs, arms, head, neck, respond in such random "wobbly" patterns that no clear structures can emerge. His discriminations likewise will wait upon discrimination adjustments.

But even at the beginning of his development the musculature of the child is not wholly disorganized. The gastric cramp will double him up in a characteristic spasm of contraction, and his cries will show a rhythmic coordination of diaphragm, chest, and jaw. At the same time his auditory receptors will be assailed by the noise of his periodic exhalations. This pattern of sound and movement has introduced an "eddy," a shape, into our biological microcosm. It has done more: the residues of this primitive shaping have given the child the wherewithal for shaping other segments of his environment. Thus, Miss Blanton found that while the newborn child was indifferent to the cries of other children, with many days of hearing his own cries he was ready to cry sympathetically. It is as though he is not properly equipped to "hear" the cries of other

[1] Quoted by Pillsbury, W. B. *Fundamentals of psychology*, p. 442. New York: Macmillan, 1934.

children until such sound patterns are attached to specific movement patterns.

The development of speech follows the same cycle. The child, in its babble in which movement and sound form similar eddies, sets up those habits with which it is later able to copy the speech of those about it, lifting out of the chaos of sound those *forms* for which it has *responses*. The adult can witness a similar process at work as he learns a foreign language and comes to reduce the rapid staccato of strange syllables, grunts, hisses, clicks, to words, phrases, meanings. His new speech habits have organized the auditory field.

Similarly, the visual field acquires its structure and form, its points of reference, as we learn to *move* in it. And again, it is not wholly without structure at the start. The spot of light which moves across the visual field catches the eye of the child and draws it in pursuit. And the child's own hand moving in front of its face ties the retinal stimulus, the eye movement, into one constellation. "Near" and "far" will emerge as the varying convergences and retinal images become tied to near and far reachings. And for the child that has not crawled, or walked, "reaching for the moon" is merely an expression of the fact that three-dimensional space does not have a structure beyond the radius of his own grasp.

Similarly, as the adult learns to find his way among the various gadgets within his radio cabinet, or under the hood of his automobile, the maze of wires, metal surfaces, and cylindrical forms assumes a pattern, order, structure. Our grasp of the material exposed is, literally, a "grasping." The organization of the perceptual field is the outgrowth of manipulation.

Viewed functionally, and genetically, perception grows out of activities. The degree to which we can impose an organization upon the sensory field is limited by the stage of organization of our movements. We group and organize the stimuli as we come to deal with them as a unit.

Motor Components in Thinking, Imagining, Perceiving.—There are many psychologists, who will give assent to the general picture of the development of perceptions which we have drawn, who will still insist that as the developmental process is completed the motor elements approach a vanishing point. While it is all very well to note that the child characteristically perceives with gesticulations (like the adult who, lacking words, tries to tell us in gestures what an accordion, a spiral staircase, or a goatee is like), the most obvious

fact is that in adult perceiving, thinking, and imagining the movement phase appears to have been *inhibited.* Or perhaps it has merely sloughed off, leaving a core of cortical responses to carry what originally was a gross organic pattern.

We have examined a few cases wherein a closer study of these apparently motionless "mental" processes have been shown to have measurable motor components (see page 345). It is doubtful, however, if experimental demonstrations of this type will ever convince the dyed-in-the-wool brain psychologist. The animistic tradition is an ancient one, and if—upon whatever grounds—one believes that consciousness is wholly an affair of the central nervous system, it will always be possible to interpret these minimal movements as accompaniments, or consequences, or precursors of the essential cortical process. Since none of the objective recordings of action in nerve or muscle carries with it any indication of its essential relation to consciousness, it would seem that the traditional dispute is likely to continue.

The chief virtue in showing that movement elements are *always* found whenever one studies what seems to be a "purely mental" reaction lies in the reminder that the brain responses are always enmeshed in an organic matrix. The brain state, at any given moment, both *reflects* the condition throughout the organism and through its pathways of motor discharge constantly alters these conditions. Thus even the brain psychologist, who thinks of consciousness as confined to higher neural structures, must envisage these higher processes in organic terms. There is not the slightest physiological evidence for positing a functional barrier between the central nervous system and the rest of the organism; and, since this is true, there is no reason for thinking of the course of thought as a chain of wholly cortical responses, with one center discharging into another until—only when the "conclusion" is reached—the stream of energy discharges into the lower structures. At every stage of the process the neural events both alter and reflect the status of things at the periphery. It is the organism that perceives and thinks, not neural tissues.

There is an anecdotal type of observation which supports this view. For example, it was noted that the blind and deaf Laura Bridgman made use of finger movements of the sign language in dreaming. All of us can note the muscle tension in our own constricted throat muscles as we listen to the unpleasant voice of the

singer with the "tight" throat. We sense our perception of the loose and peeling bit of plaster, or sunburned epidermis—if we turn, in introspection, from the external object to our own responses—in our own itch (incipient movements) to peel it off. We resist, with difficulty, the impulse to straighten the frame of the poorly hung picture, or to straighten the necktie that is disarranged. We can scarcely continue eating without doing something about the food particle resting on the lip or chin of our table companion.

Jacobson's Experiments.—Recently a more impressive type of evidence has appeared. Dr. Edmund Jacobson, whose studies of relaxation have been mentioned earlier, attempted to find experimental evidence of these incipient motor responses in what we would commonly call purely mental activities. Using the method of thermionic amplification of the minute electrical responses which appear in minimal contractions of muscle, and a string galvanometer method of recording, sensitive to one-millionth of a volt, Jacobson attached electrodes to his subject, instructed him to relax (in a dark, partially soundproof room), and recorded what ensued.

When the subject was completely relaxed the recording galvanometer produced a straight line record. Within a fraction of a second after the subject carried out the direction "Imagine bending the right arm" deflections appeared in the right-arm line of the record; when the signal "Relax" followed, the deflections ceased. These electrical changes which give positive evidence of motor processes (electrodes were attached to biceps-brachial muscle and skin in elbow pit) also appear when the right arm is contracted; they do not appear when the subject is instructed to

Imagine bending left arm
Actually bend left arm
Imagine right arm perfectly relaxed
Imagine extending the right arm
Do not bother to imagine.

These facts show that the action current is a specific, rather than a general effect; that it is not due to any general sound effect of the signal, or to the general task of imagining a movement.

Even more striking is the result when the subject is asked to imagine hitting twice with a hammer in the right hand (see Fig. 81). When more complex activities were used—sweeping a room with a broom, rowing a boat, boxing, picking a flower, etc.—the results were not uniform (14 out of 28 trials showed positive results); but

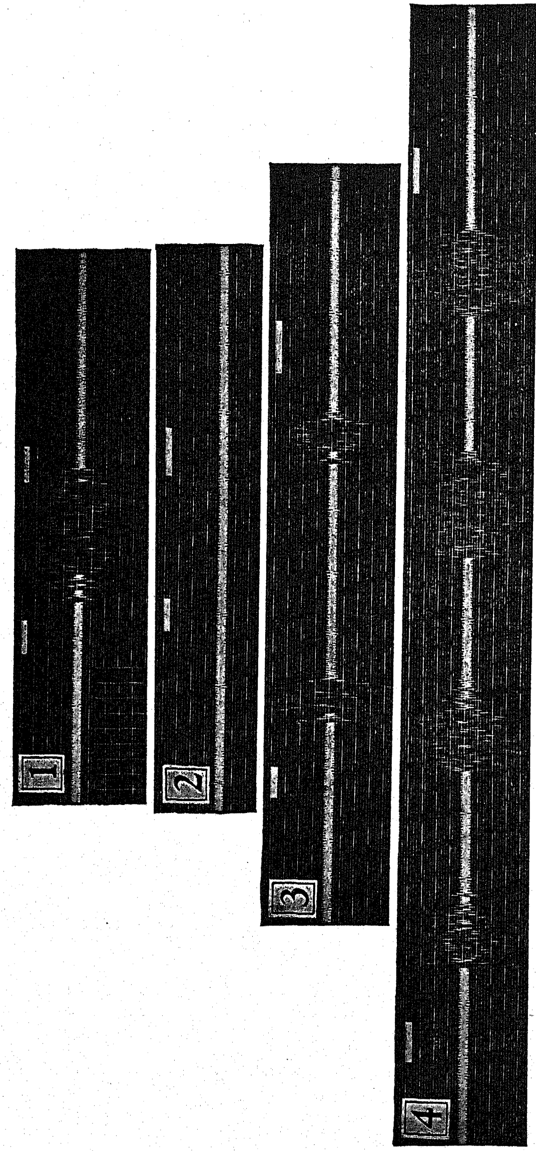


FIG. 81.—Photographic record of galvanometer deflections. Signal marks indicate onset and cessation of imagination of actions. Instructions were: (1) imagine lifting a 10-lb. weight with the right forearm; (2) imagine lifting the weight with the left forearm; (3) imagine hitting a nail twice with a hammer held in your right hand; (4) imagine performing a rhythmical act (*e.g.*, climbing a rope, chinning on a horizontal bar, etc.). Electrodes attached to right arm. (*From E. Jacobson. Electrophysiology of mental activities. Amer. J. Psychol.*, 1932, 44, *p.* 682. *By permission of the publisher.*)

when the subjects were first asked to name activities which they would naturally perform with the right arm, the experimenter obtained results in 97.5 per cent of the cases (159 out of 163 cases) and all the controls were negative.[1]

Similar procedures which involved the eye muscles (imagine the Eiffel Tower, imagine looking to the right, etc.) and the lips and tongue (counting, recalled a poem, etc.) also yielded positive results when the task called for activity in the musculature under observation. Jacobson's subjects also showed that when the instructions "Relax" and "Imagine" coincided, both could not occur. Thus, it would appear that "imagery," "inner speech," remembering, perceiving, can no longer be regarded as confined "to closed circuits within the brain but that muscular regions participate."

Eye Movements in "Imagining."—Evidence from the work of another investigator corroborates these findings. Miss Totten,[2] who did not attempt to record the electrical changes in the musculature, took photographs of the eye movements of her subjects who were asked to imagine objects with a clearly defined geometrical character (*e.g.*, Washington Monument in Baltimore, freight train standing still on the track, two men sitting, one at each end of a long table). Although her technique was not the most refined possible, her results showed a visible conformity between the minimal movement and the object imagined (75 cases were positive, 9 negative, and 21 doubtful).

The Gestalt Psychology's Approach to the Problem of Perception

The account of the perception process which we have given contains two tendencies which are sharply attacked by modern Gestalt psychology. Perhaps an examination of the main tenets of this school will serve as a wholesome corrective to the views we have achieved so far.

The two tendencies to which we refer are: (1) the tendency to emphasize the role of experience and to explain "meanings"—in fact, the whole structure and organization of perceptions—in terms of *past* organizing and structuring activities; (2) the constant

[1] Jacobson, Edmund. Electrophysiology of mental activities. *Amer. J. Psychol.*, 1932, 44, 676–694

[2] Totten, E. Eye-movements during visual imagery. *Comp. Psychol. Monogr.*, 1935, 11, No. 3.

attempt to reduce all totals, or "wholes," to atoms, or units (whether of sensations or of reflex movements), and to view the "totality," the configuration, as somehow an additive affair. Both these tendencies are viewed as pernicious by the Gestaltist, and a large portion of his energy as experimenter has been devoted to the demonstration of their unfortunate consequences for psychological knowledge. He is even ready to supply a new logic, a new mode of reasoning about the world (and not merely of things psychological), for he feels that it is in part due to this faulty tool that we have fallen into a false "mode of conceiving."

The Antiempirical Emphasis.—The psychological explanations of a given sample of human activity tend to reduce to two: we look for "original," innate, structural-functional units (reflexes and

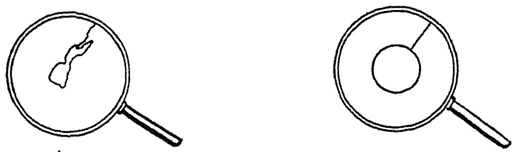
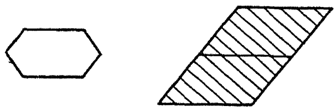


FIG. 82.—Diagram illustrating physical gestalt. A thread loop is loosely embedded in a soap film at the left. If the film within the loop is pricked the result shown at the right appears.

"instincts") and we look for a shaping and organizing process in the past whereby these have been organized. The Gestaltist insists that there is a third process, and in his eagerness to demonstrate its potency he is inclined to minimize the value of the heredity-habit type of analysis.

The third factor is a dynamic one, and arises in the interplay of forces at the moment of perception. Out of the interacting system that is set up at any given moment, out of the interplay of forces, there will arise a *structure*, a configuration, an *organization* (in both behavior and consciousness), and this structuring process may be viewed as an equilibrating one (*i.e.*, as determined by physical field properties) which can therefore arise without previous "experience." A favorite Gestalt analogy is that of the thread loop embedded in a soap film suspended upon a wire loop. By carefully pricking the film which lies within the irregular loop of thread a "figure" suddenly emerges, the tensile forces of the soap film which remains distribute themselves automatically so that a circular opening is formed. No one would think of invoking a "practice effect" to account for such distribution. We might substitute a

new thread, a different wire support for the film, or new soap solution, and if we kept the essential relations constant we should repeat the phenomenon. Thus, we may conclude that "Gestalten" (or structures) are natural phenomena, the product of the interplay of field forces, and that they are neither the additive sums of the units composing them (*i.e.*, not due to the properties of the atoms taken as such) nor the residues or traces of "previous" organizations. In fact, the Gestaltist is likely to urge that, if we seek always to explain the present organization in terms of some preceding organizing



(a) (b)

FIG. 83.

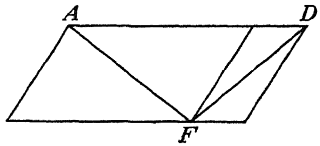


FIG. 84.

FIG. 83.—Gottschaldt's figure. Notice the (*a*) figure embedded within the (*b*) figure. (*From K. Gottschaldt. Uber den Einfluss der Erfahrung auf die Wahrenhmung von Figuren.* I. *Psychol. Forsch.*, 1926, 8, *p.* 296. *By permission of the publishers.*)
FIG. 84.—Sander's parallelogram illusion.

process, we shall be confronted with an insuperable task when we face the earliest organizations.

From the mass of experimental findings we may select one experiment as typical of this Gestalt emphasis. Gottschaldt[1] presented, in a "training" series, figures which were later "embedded" in a large configuration. Thus, in Fig. 83, the (*a*) figure can be found embedded in the large (*b*) figure. Showing the subjects the smaller (*a*) figure as many as 500 times did not appreciably improve their chances of seeing it when the larger configuration was exposed. Why? The Gestaltist answers that the reason is to be found in what he has come to accept as a general proposition: the properties of a "part" are determined by the total configuration in which it functions.

The Antiatomistic Emphasis.—The second emphasis is neatly illustrated by Sander's figure (Fig. 84). When the lines *AF* and *FD* are compared, the "wholes" of which they are a part determine the judgment. Although one is a short diagonal and the other a long diagonal, it is the relative size of the parallelograms that is operative. As soon as the triangle *AFD* is "lifted out" the sides assume a new

[1] Gottschaldt, K. Über den Einfluss der Erfahrung auf die Wahrnehmung von Figuren. 1. *Psychol. Forsch.*, 1926, 8, 261–317.

relation. Thus, we achieve the proposition that contours belong to the figures of which they are a part. Again it is the whole which determines the character of the part.

An experiment by Fuchs[1] illustrates a similar type of determination in another field. A nine-point dot figure composed of dots of yellow, yellow-green, and blue, with the yellow-green dot in the center, may be seen as a yellow plus sign (+) or as a blue-green cross (x). When the cross sign is seen (and a yellow square can be seen at the same time) the central dot is bluish-green, as are the other dots of the same figure; and when the yellow plus sign is seen, the central dot appears yellow.

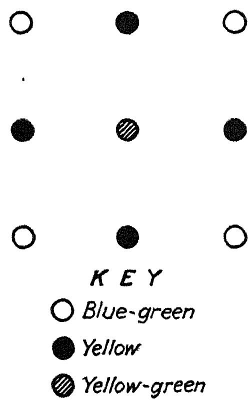


FIG. 85.—Diagram illustrating Fuch's method of showing the influence of form upon color quality. The middle circle appears yellow when it is seen as a part of a plus sign, greenish if part of an *X*.

Similar facts might be reported from other sense fields. As a matter of fact, the Gestalt-approach has been applied to nearly every important psychological problem, and the fruitfulness of the viewpoint is proved by the impressive mass of new facts which have been turned up. Even the oldest experimental findings, such, for example, as the Weber-Fechner law, are seen to be but special cases of their general proposition. (As, for example, when the just-noticeable increment of weight is seen to be a function of the total weight lifted.) In the auditory field, for example, it is found that thresholds and pitches are found to be functions of configurational factors. In the tactual field, it is found that the distance separating two points—necessary for their perception as two separate stimuli—depends upon their position in tactual figures.

Perhaps the most dramatic illustration of the Gestalt principle, however, is found in the pioneer experiments of Wertheimer. When two points of light are successively made to stimulate the stationary retina, and the spacing and timing of the stimuli fall within certain rather exactly defined limits, the subject will see an apparent movement of the light from the first position to the second. We say "apparent" movement because we know (from our construction

[1] Fuchs, W. Experimentelle Untersuchungen über die Änderung von Farben under dem Einfluss von Gestalten. *Z. Psychol.*, 1923, 92, 249–325.

of the apparatus) that the lights do not move, but the subject's experience is a perfectly genuine one; he "sees" the light move. From two momentary and stationary stimuli a third thing has arisen, "phenomenal" movement. Whether we conceive of the underlying physiological process as some type of "between process" in the cortex, as a center of electrochemical change moving to a new area—activating intervening tracts, or whether we think of a shift in neuromuscular patterns of a much more widespread character, it is clear that we are dealing with a dynamic, relational system whose properties are not to be deduced from punctiform elements, statically considered.

When the Gestaltist is able to show that these same field properties appear in the reactions of the child and in the behavior of animals, their primitive and universal character is offered as proof that they are indeed the basic considerations in any account of animal conduct. The formulation of the "dynamic" laws which govern the emergence of these figures would replace those stimulus-response formulations which treat of isolated stimuli, or nerve paths, of synaptic resistances, etc. Instead of beginning with a somewhat theoretical physical and physiological analysis, we should begin with behavior as we find it. Certainly we must admit that it is at present impossible to deduce the facts of human conduct from known physiological laws (discovered from an examination of part processes). To the Gestaltist this will appear as natural and inevitable; a true physiology of behavior can be built only out of "totals" (*i.e.*, total organisms and total situations).

The Gestalt Laws.—There are two types of questions which we might conceivably ask the Gestaltist: (1) How do "structures behave"? and (2) How shall we control the arousal of such structures (*i.e.*, upon what limiting conditions do they depend)?

Configurational Laws.—Here we desire more than slogans. The Gestaltist has provided many of these, such as

Function determines (or utilizes) the mechanism
The whole is more than the sum of its parts
The configuration determines the function of parts embedded within it.

Such slogans will serve to warn us against making a fetish of the physical description of the stimulus; for the Gestaltists have warned us (and demonstrated) that, while the physical units condition and activate the responses of the organism, we must not expect the latter to "correspond" to the former. But, on the other hand, they

suffer from a certain vagueness. To say that "function determines the mechanism" is about as valuable as to say that my leg movements are determined by my purposes (rather than that my leg movements determine whither I shall arrive). Such a slogan may serve to orient us, somewhat vaguely, toward the description of totalities, purposes, wholes—but it does not give us an answer to the scientific question, "How?"

Among the answers formulated by the Gestaltists are certain "laws" which we shall have to consider:

1. THE LAW OF PRÄGNANZ.—If we regard the structuring process as one in which a field of forces achieves, through time, an equilibrium, we shall be prepared to understand why certain figures are more stable than others, and why the less stable ones tend to move toward the "end state." As examples of the process, consider the following cases:

FIG. 86.—Wulf's memory figures. The drawing at the left represents initial impressions, the one at the right the delayed impressions with a sharpening of the features perceived. (*From F. Wulf. Über die Veränderung von Vorstellungen. Psychol. Forsch.* 1922, 1, *p.* 337. *By permission of the publishers.*)

When we fixate the eye upon a small red square for a few seconds, and then turn to a neutral surface to study the afterimage, the form of the latter is seen to change until its blunted corners disappear altogether and a smaller circular figure is seen.

When we arrange three, four, six dots around a center, they are "seen" as grouped in triangular, quadrilateral, hexagonal patterns. If now we increase the number to eight we see the dots as "arranged in a circle." Like the soap-film and thread illustration, we seem to be dealing with a field under stress: the "figure" representing a "steady state," a condition of equilibrium.

The Gestaltist is wont to describe these end states as conditions of greater *simplicity*, *symmetry*, *uniformity*. He sees them as giving a maximum of "precision" with a minimum of "work," obeying a "law of least action."

The law of Prägnanz must not, however, be understood simply as a leveling process. Wulf[1] found, for example, that when he asked his subjects to reproduce exposed patterns under certain conditions curves and angles were accentuated (see Fig. 86).

[1] Wulf, F. Über die Veränderung von Vorstellungen *Psychol. Forsch.*, 1922, 1, 333–373.

We are thus left with a statement that is not altogether free from obscurity. On the one hand, the terms "simplicity," "symmetry," "uniformity" do not have the exactness and applicability that one could wish; on the other hand, one law is made to cover apparently contradictory tendencies, for in one case we are told of a drift toward simplicity and in the other we see a process which results in greater precision, in accentuation of details. Shall we say that the law of Prägnanz accounts for the severity and symmetry of modern architecture (and of the Greek); and at the same time appeal to this law to account for Byzantine and Gothic (and rococo) styles. Clearly the law of Prägnanz lacks precision; the verbal facility which it provides to the one who would explain phenomena (after the fact) is more than counteracted by its uselessness as an instrument of prediction.

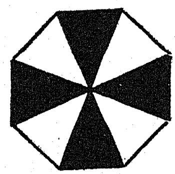


FIG. 87.—Iron cross figure. (*After Edgar Rubin. Visuell wahrgenommene Figuren. Copenhagen and Berlin: Gyldenalske Boghandel,* 1921.)

One cannot but be suspicious that important physiological processes are concealed (and neglected) by this type of formulation. It was noted, for example, by Rubin that, when an ambiguous figure (double cross, Fig. 87) is exposed, it is much easier to hold the vertical-horizontal cross as a figure than the inclined one. Hartmann,[1] commenting upon this early finding, sees in it a beautiful illustration of the law of Prägnanz. But one at once wishes to know why precisely this structuring of space is more "precise," or symmetrical, or simple; and one can scarcely resist the attempt to relate it to those postural mechanisms which Magnus has described, to the gravitational reflexes which are certainly basic to our whole spatial orientation.

And, as we shall see in a later examination of the memory problem, there is ample reason to believe that the tendency toward greater precision can be explained (often at any rate) by appeal to experiential factors as well as by the vague Prägnanz principle. The drift in the retained "trace" is toward the typical, toward the stereotype, toward the culturally supported pattern. In one respect there is no opposition here to the Gestalt formulation; for this version again amounts to the statement that the behavior of any exposed item depends upon the "whole" that is perceived. But if it is a question of "assimilation" to a familiar stereotype, then

[1] Hartmann, G. W. *Gestalt psychology,* p. 27. New York: Ronald, 1935.

obviously the principles of symmetry, accentuation, leveling, etc., are useless; for, if the stereotype is a very precise and highly structured one, then the tension, or trend, will not operate in the direction of greater simplicity, but rather in the direction of "completion of the figure."

2. The Law of Closure.—Incomplete figures tend to complete themselves. Just as heterogeneous facts move us to order and classify them (that is, after all, the only way we can handle them and free ourselves from the anxiety and tension of an uncertain and unstable condition), so an all-but-complete figure "demands" the completing elements, and the closer we approach to completion the greater the tension toward completeness. Thus, the familiar melody or phrase, arrested just before completion, arouses an irresistible tension. The tune which we can't quite complete haunts us for a day. An incomplete figure is an unresolved tension.

In one sense this law is but a special case of the law of Prägnanz, for in moving to completion we are achieving that end state, that stable distribution of forces, of which this law speaks. When, for example, we place a small triangular figure (strips of brass, inch-long) on the surface of the forearm of a blindfolded subject, we find that it is possible to separate the ends of two of the strips by a distance much greater than the two-point threshold of the area without the subject's awareness that the tip of the figure is "open." Like the "portion of the visual field which falls upon the blind spot" of the retina, there is a *filling in;* and, as in the case of Wertheimer's phi-phenomenon (the "seen movement"), it does not appear to be necessary to appeal to experiences which accomplish this filling in.

Figures, arrangements, forms are thus seen to have dynamic properties, "implications." The evocative powers of the all-but-complete melody do not reside in the individual intensities and pitches, additively conceived, but in their "formal" arrangement. In fact, this dynamic quality may be retained even when each of the parts is altered—provided essential relations persist. It is this aspect of the configurational problem which provides the Gestaltist with his cue to the memory problem. It will be this dynamic property of the configuration which will determine the memories invoked, not the mere presence of "common elements," conditioned stimuli. To the oft-repeated query which we raise, "Why didn't I think of it at the time?" the Gestaltist will respond, "Because the elements which now seem so obvious were

then embedded in another figure." And in the same way the implications and impulsions toward solutions, future actions, will be seen as arising from a present dynamic situation. To diagnose or define a present situation, to organize it, to respond to relations, is at the same time to experience its implications, to project action into the future. Thus the clinician meets a configuration of symptoms, no one of which in isolation can be "read"; yet out of the total clinical picture arises a "diagnosis"—with therapeutic implications.

3. The Law of Development (or Individuation).—The development of our perceptions might be roughly compared with the manner in which clear outlines emerge from a fog. The passenger carried by his boat into the harbor sees crude masses (figures emerging on a background) which are poorly "structured" (*i.e.*, vaguely defined). The visual field has little "depth." As he draws nearer to the shore the "figures" grow more articulate, the nearer buildings "stand out," sometimes "leaping" to their positions (as though he shifted from one-eyed to stereoscopic vision). Throughout this process of development and differentiation it has been a matter of "totalities," of field properties, of figure and ground. One whole succeeds another; the process is one of progressive individuation rather than of some sort of additive combination.

Now it is argued that the development of perceptions in the child takes place in a similar fashion. The primitive, undifferentiated wholes are broken up—not into isolated fragments, but into more highly structured patterns; and during this process of progressive individuation configurational laws reign (*i.e.*, the dynamic part-whole relationship is never broken). The child, for example, has difficulty in abstracting the color or form from the object; he reacts to a totality with comparatively simple structure. So, too, his movements are massive limb-trunk affairs; and just as this total posture breaks up into the steadier support or fixation with the rapidly flung and accurate movement of eye or extremity appearing as "figure" (and the latter is never independent of or free from the influence of this supporting matrix), his perceptions grow more highly articulated, structured.

There is also a parallel in the contrast between primitive and "civilized" thought and speech. When we turn to the former, with our modern sophisticated equipment, it seems curiously illogical, undiscriminating. The primitive's refusal to recognize distinctions, his tendency to fuse things which we consider separate, his indiffer-

ence to "contradictions," makes him seem to be mystical; we consider his thinking as "fuzzy," and his mentality as childlike. He is willing to entertain the possibility of being in two places at once, to endow inanimate objects with attributes which we reserve for animals or human beings. Instead of having a common name for all cows he has a separate one for red-cow, brown-cow, black-cow, and his vocabulary gives no hint that he sees anything in common between red-cow and red-sunset. He gives evidence of confusing his own feelings and impulsions with the objects which he views.

Our own language gives ample evidence of this same tendency, especially when it becomes metaphorical and poetical. We speak of bitter facial expressions, piercing tones, lonely clouds, etc. In all probability those "intrinsic" goods and "intrinsically" beautiful objects, which clutter our discussions of ethics and aesthetics, are just such undifferentiated totals in an experience that is as yet insufficiently structured for us to abstract significant relations. Perhaps our political thinking suffers most of all from this lack of structure; it is probable that a few centuries hence men will look back upon our formulations of the social question as decidedly "primitive."

The import of this Gestalt emphasis is that an adequate history of development, whether of a culture, a child's motor coordinations, or an adult's perceptions, can be made only by considering totals, by constantly viewing each part in relation to a larger dynamic whole. The reverse procedure, which has occupied us in the past, of beginning—as in psychology—either with a reflex equipment, with sense organ, neuron, effectors, or with "sensations" (which were to become united into additively conceived "perceptions"), will not work. The sensation turns out to be the last thing acquired, a highly structured and differentiated perceptual figure; and the isolated reflex which operates mechanically without a subjection to an organic whole turns out to be a physiological fiction.

The Conditions under Which Configurations Arise.—We turn now to our second question, seeking those limiting conditions which seem to govern the emergence of a structure. When we are confronted with a heterogeneous group of stimuli they take on shape, some of them seem to advance into the foreground to form a figure while others retreat into the background. What determines the role which any part plays, and what governs the appearance of the "figure?"

In one sense we are in danger of falling into a circular type of reasoning. We argue that its role in the figure determines the action of a part; are we then to ask how the part determines the figure? It is this last question which the Gestaltist has ruled out as illegitimate, for his central thesis is that the part, as part and in isolation, does *not* determine the figure! The factors, therefore, which govern the appearance of the figure will have to be, themselves, relational and configurational factors.

Before examining the principles which the Gestaltist has advanced, it may be well to emphasize one point, and briefly to reaffirm this configurational emphasis. It has long been known that the "background" of stimulation upon which a light or sound stimulus appears is a factor which alters the threshold, and may determine whether a stimulus is perceived or not. All are ready to accept the fact that a stimulus is a "step-wise" change. Lifted-weight experiments show this. It remained for Gelb and Granit[1] to show further that the size of the step necessary to produce a perceptual response was further influenced by the role of the supporting background in a total configuration. Thus when the Maltese cross figure (similar to the one shown in Fig. 87) was viewed through a blackened tube so that a reversible figure appeared, it was found that the intensity of a spot of red light had to be *greater* (if it was to be perceived) when the portion of the cross on which it fell functioned as "figure" than when it functioned as "ground." The pattern which "stands out" seems to possess at the same time some type of internal coherence. It seems to "resist" being forced into the background role.

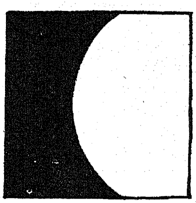


FIG. 88.—Simple drawing illustrating the manner in which the properties of a line are altered by the figure to which it belongs.

In the same way the Gestaltist has pointed out that the properties of lines, or contours, are altered by the field to which they belong. Thus in Fig. 88 the borderline separating the two areas is convex when the dark portion is taken as the object, or figure; it becomes concave when the black becomes the background.

It is apparent, too, that when we deal with reversible figures of this type (cf. Fig. 89) the figure-ground relationship constitutes one dynamic whole, and does not change gradually, bit by bit, but

[1] Gelb, A., and Granit, R. Die Bedeutung von "Figur" und "Grund" für die Farbenschwelle. *Z. Psychol.*, 1923, 93, 83–118.

"flops" suddenly—or not at all. Part and context, figure and ground, are thus dynamic systems whose laws must be discovered *in such systems*, and not deduced from the properties of the parts, studied as such.

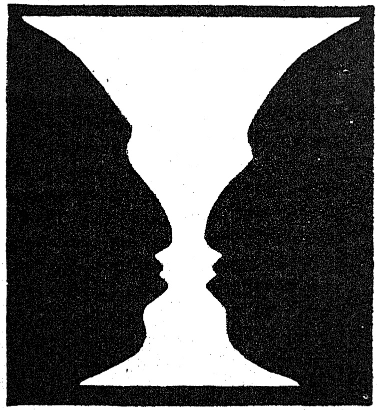


FIG. 89.—Rubin's vase figure. (*After Rubin. From S. I. Franz and K. Gordon, Psychology*).

Nevertheless, we can arrange situations. If our practical aim is that of an educator, for example, we must know the necessary features of these arrangements if we are to facilitate the "insights" of our pupils. It is not enough to accept the figures, as they emerge, with natural piety and to see each new situation as a special instance of the formula, "The whole is greater than the sum of its parts," or its companion, "Function utilizes mechanism." If, as appears to be the case, the Gestaltist is going to substitute the "configuring" process for "attention" (and it is true that the figure is that which is attended to), then he must meet the same practical question which was faced by an older psychology under the heading, "Conditions of Attention." Among the relations stressed by the Gestaltist we may note the following:

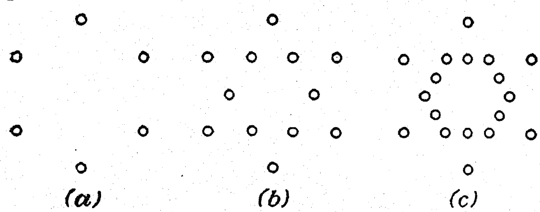


FIG. 90.—Dot figures illustrating the factor of nearness. The hexagon which is clear in (*a*), is less clear in (*b*), and reappears in (*c*) as left-over group. The interior hexagon in (*b*) becomes clearer in (*c*). (*From R. S. Woodworth. Experimental psychology, p.* 626. *New York*: *Holt*, 1938. *By permission of the publishers.*)

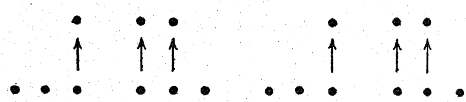


FIG. 91.—Dot-figure illustrating the principle of "common fate." (*From G. W. Hartmann. Gestalt psychology, p.* 96. *By permission of the publishers.*)

1. Perhaps the simplest factor is that of *nearness*. We can see it, for example, in Woodworth's dots (Fig. 90). Temporal successions of sounds will likewise fall into patterns when the temporal intervals vary in a similar manner.

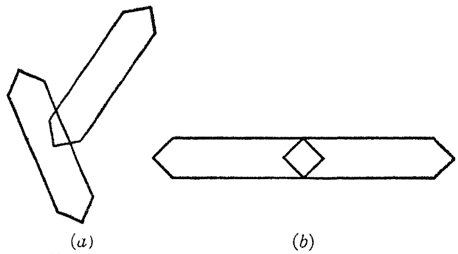


FIG. 92.—Figure illustrating effect of different arrangements of parts upon resultant figure. (*From M. Wertheimer. Untersuchungen sur Lehre von der Gestalt. Psychol. Forsch.*, 1923, 4, 326. *By permission of the publishers.*)

2. *Enclosure* is a second factor of this type. Other things being equal, the enclosing (or continuing) stimulus field tends to provide the background; the enclosed (or momentary) stimulus group, the figure.

3. *Vertical-horizontal* groupings have an advantage over other arrangements. (We have already hinted at possible postural explanations for this factor.)

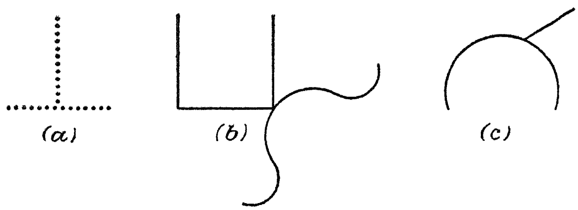


FIG. 93—Figures illustrating Wertheimer's concept of "Innigkeit" (or intimacy.) (*From M. Wertheimer, op. cit., Fig.* 1, 8, 15. *By permission of the publishers.*)

4. What Wertheimer called the principle of "*common fate*" may be illustrated by an arrangement of dots, as in Fig. 91. If, in the figure, the points *c*, *d*, *e*, and *i*, *j*, *k*, (if we think of the dots as lettered from left to right) move upward above the line at the same time, their common displacement, or destiny, will result in a new grouping. This latter factor is more difficult to place as a spatial-temporal factor; for it raises the whole question of what constitutes a *similar* change. It suggests that rates of

change (and acceleration) as well as pattern of change, and goal, may operate in segregating and uniting otherwise heterogeneous elements.

5. The principle of *continuity* summarizes the fact that in forming figures from given boundary lines we tend to make constructions in which the lines continue uninterrupted, with as little (or as gently changing) deflection in direction as possible.

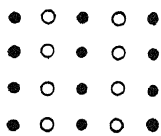


FIG. 94.—Figure illustrating "likeness" factor. (*After M. Wertheimer, op. cit., p.* 309. *By permission of the publishers.*)

Thus, we see Fig. 92 (*b*) as a long hexagon with small rectangle included, although the lines actually permit its organization into two overlapping figures of the shapes and dimensions portrayed in (*a*). We see the dots in Fig. 93(*a*) as a horizontal line with perpendicular erected in the middle, and we do not "break" it up, easily, into a right angle and straight line. The principle is easily applied, too, to parts (*b*) and (*c*) of the same figure.

6. The principle of *likeness*. In a stimulus field containing a number of like stimuli there is a tendency for the latter to be grouped, to "flow together." The dots in Fig. 94 are readily seen in vertical rows, for example.

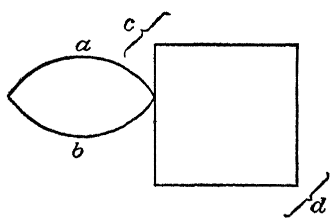


FIG. 95.

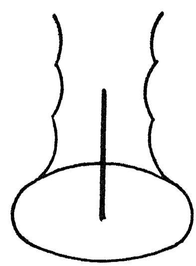


FIG. 96.

FIG. 95.—Figure illustrating the principle of closure. (*From M. Wertheimer, op. cit., Abb.* 26. *By permission of the publishers.*)

FIG. 96.—Figure illustrating the subordinate role of experience. (*From M. Wertheimer, op. cit., Abb.* 53. *By permission of the publishers.*)

7. The principle of *closure*. Of two organizations which are possible—one complete and enclosed, the other incomplete and open—the former tends to dominate. Like the theory which covers *all* the facts (in contrast to the one which covers but a few of them and then compensates for its inadequacy with qualifications and special cases), the inclusive Gestalt is both stable and preferred.

Thus, in Fig. 95 we see two enclosed processes, instead of the possible arrangement composed of *ac* and *bd*.

8. The principle of *eidotropy*. The Gestaltists do not deny that there are such things as habitual modes of conceiving, and in so far as we tend to isolate the "typical" pattern, to force the new configuration into the mold of our stereotypes, the principle of eidotropy holds. That Gestalt psychologists regard this as a principle of subordinate value or power is evidenced by the prominence which they assign to such experimental studies as those of Gottschaldt. Again, in Fig. 96 we can see how the factors of organization obscure the familiar 3 and 4 which we have seen so many times. In fact, it would be much nearer to the Gestalt view to say that the dynamic factors at work at the present moment determine which of our past organizations shall function than to take the reverse position, which would explain the present emergence of a figure on the basis of habitual actions, synaptic traces, past conditioning.

The Gestaltist's view of habit is somewhat like the view of orthodox psychology in the matter of telepathy. We are apt to explain the fact that similar ideas arise in the minds of independent observers by pointing out that each is probably responding to the same stimulus, or cue. The Gestaltist is apt to explain the fact that an "old" configuration arises, *not* because it is old or because these particular stimuli have invoked it before, but because the same dynamic factors now operate.

In fact, it would seem to be the logical implication of Gestalt psychology that, while events leave their traces in our organism, the individual configurations are as evanescent as a smile. For what is the upshot of the Gestalt experiments on learning: do they not point to the fact that what we call a habit is in no sense a fixed sensorimotor coordination? New sensory endings can bring to the central nervous system the same configurations, new constellations of muscle fibers can accomplish the same movement (functionally described in terms of activity served). Such facts are difficult to reconcile with any synaptic resistance theory: they do not permit us to think of our set of habits as any static set of structures. The storehouse of memory is not an attic filled with old garments and pictures. It is, rather, the fluid, living stuff of the organism; and if in this fluid matrix patterns repeatedly appear, and experience somehow accumulates and complicates the structure

of our behavior, the "miracle" of each new configuration will have to be explained on the spot in dynamic terms. We cannot build the present figure out of old forms pulled from the attic of the mind; the Gestaltists have set fire to the attic.

In truth, the Gestalt solution has turned into the Gestalt *problem.*

9. The principle of *objective set* (Einstellung). In a sequence of stimuli (successive configurations) there may appear a trend. This dynamic factor, subjectively experienced as "expectancy," will influence the present organization. Thus the exposure of a series of lines of increasing lengths will produce an overestimation of the final one if the objective length of the latter is slightly less than the series "implied." Whether any such trend is experienced or not, the just-preceding activities—as they fade—provide a background upon which the present stimulus must fall. Thus a "fourth dimension" is introduced among the determinants of perception.

The factors of both habit and set introduce the old familiar determinants of attention. They serve to call attention, too, to a fact which might easily be missed in many Gestalt accounts, namely, that the organism is by no means a passive part of the situation within which configurations are formed. Dealing, as he so frequently does, with the phenomena of visual perception the Gestaltist sometimes gives one the impression that the dynamic factors are *out there* among the stimuli, that it is the spatial nearness, continuity, etc., acting upon the retina, which results finally in cortical organizations. Then, and only then, does the organism appear as the *executor* of these cortical patterns.

The study of motivation has convinced us, however, that motivating factors are both internal and external. The dynamic field within which configurations emerge must include the organism, and all its impulsions. As in Ogden's version of the Gestalt view of learning, it is "under the stress of a felt want" that the field takes shape. These "felt wants" are deeply rooted within the organism and extend far below and exist prior to the highly structured consciousness of the adult. They reach into the "physiological unconscious" of visceral tensions, and beyond into the chemistry of nerves, blood, and muscle cells.

CHAPTER X

THINKING

An Inner World

Behind the surface activities which can be directly observed and measured lies an inner world of thoughts, some of which we can communicate to others by means of words and gestures and some of which "lie too deep for words." Although we commonly accept a contrast between thought and action (do we not encourage the too-impulsive youngster to "stop to think," and has not the sculptor modeled the thinker as seated with chin cupped on hand and elbow resting on knee?), we know full well that the stream of activity continues even though, like an underground river, it has temporarily dipped beneath the surface.

We know from observation of ourselves that sometimes this hidden stream flows lazily and with little coherence. In reverie our thoughts meander, lazily moving within the channels of habit. The thought of summer reminds us of a summer camp, and this in turn of fishing, tackle, a mail-order catalogue, an item needed for a long-neglected repair on the house, a poor workman employed a year ago, etc. At other times, as under pressing circumstances or when absorbed in an interesting task, the stream breaks through new channels, and there is an internal coherence and consistency—the thoughts appear in order and directed toward an objective. For the most part there is a warmth and familiarity about all these events; they are *our* thoughts, *our* plans, *our* reveries, and they are (naturally) sensible and proper. But occasionally (as in dreams—and especially in certain pathological states) they may seem foreign, bizarre, or unworthy of that "better self" which we like to think of as somehow in control.

We lapse easily into figurative language in describing thought, in part because it is so intangible; but like all analogical thinking, such language is both inaccurate and misleading. Our problem, therefore, is to relate this inner stream of activity, functionally (and in as exact language as we can command), to the more easily

observed overt responses. And we shall have to face the problem created by our figurative language itself when we speak of an observer (on the one hand) and thoughts which are the object of his inspection (on the other). And what meaning and functional significance can we give to those thoughts which lie "too deep for words" and to the implied dichotomy between conscious and unconscious processes?

Thought and Action

When one hears the voice of a friend over the telephone, the words, the quality of voice, the inflections, conspire to arouse a familiar mental picture; moreover, one whose expressions are congruous with what is heard. On the other hand, an "action picture" seems almost to speak, as though the visual cue aroused a faint auditory echo. We have already met this phenomenon in our discussion of perception. Is it not possible that the trains of images which we find in the stream of thought are simply a series of conditioned responses similar to those which figured in perception?

These images may lie in any sense field. That is to say, our images of yesterday's football game may be in terms of revived responses-to-sound (the yells, the "thwack" of the booted pigskin, the band music, etc.); or in terms of revived visual-motor responses (the gay uniforms and strutting drum major, the charging team, the long end run, the contortions of the cheerleaders); or in more obviously motor terms (tensed postures, straining throat and chest muscles, gesticulations); or in responses which were originally cued by olfactory, tactual, temperature senses. As surely as each sense modality invokes a characteristic type of response (which we experience as a unique quality), the image (revived response) may bear this same quality, although it is commonly weaker in intensity, less sharp in "outline," etc.

The movements which we make during such revival are commonly so slight as to elude even close observation; but the work of Jacobson (see page 477 ff.) and others has demonstrated that with proper instrumentation they can be revealed, at least under relatively simplified circumstances. Such demonstrations, admittedly, cannot in themselves convince the "brain psychologist" that an image *is* itself a sensorimotor affair; for he finds it easy to describe the implicit movements as the *consequence* of an imagery that is located somewhere in the brain. At the moment, it does not seem particularly important whether we insist that the movements are a vital

part of the imagery process or merely its occasional consequence, for recording techniques have not advanced to the point where an experimental solution is possible. Neither action-current records of brain nor those taken from muscle permit us to make an objective record of the image which can be read, and in the light of some of the characteristics which we shall discuss it seems highly probable that the purely physiological study of these processes will always have distinct limitations. We can ask a subject to report what he is experiencing; we can study our own reactions; we can observe a subject's performance in those situations in which imagery plays a role (asking him to draw the figures he visualizes); but we have not, as yet, found any way of studying the imagery of another in any direct manner. For this reason any statements about its physiological character are, of necessity, speculative, and the "facts" about the image will have to be given on an entirely different descriptive level from that employed, for instance, in recounting the effects of excess thyroxin.

Even those who speak of movements as the "carriers" of imagery (instead of purely cortical responses) assert that the contractions involved are very slight. If the twitching of his forepaws really signifies, as we sometimes imagine, that the dog asleep on the hearth-rug is dreaming of the chase, this "motor image" is certainly the merest shadow of that which it represents. Similarly, the slight change in our breathing as, in reverie, we think of some exciting past event is no more than the barest suggestion of those former changes. It is true that there are cases where the image is more powerful. We may find ourselves shifting our postures, grimacing, when we momentarily lose ourselves in the daydream. Wakened from the nightmare, we find ourselves bolt upright in bed, shouting.

Normally the response is a fragmentary one. We "wash our hands" of a situation, in thought, with (at most) the merest vestige of the movements of rejection which the real situation would require; our planning of the events of the coming day is telescoped within a few seconds of imagery. Our contracted brows, the rapid glancing over the materials on our desk, the fragmentary subvocal naming of the tasks, and perhaps a hasty jotting on a memo pad, are all over in a moment: the completion of the tasks projected will fill a day. Yet we say we have "thought out" our plan of action.

It is in this fragmentary character that the efficiency and usefulness of the image-response lies. With a brief movement of our

eyes across the map we travel, in thought, from Cleveland to New York. The experienced chess player may project his future moves, in imagination, without giving his opponent a clue, without shifting a piece. Where simpler organisms and novices must actually go through with a whole movement sequence, shifting the items in their environment or moving through the latter, in order to discover consequences, the experienced man can think out the solution with great economy of time and energy, and in privacy.

In summary, then, we may describe a "thought" as *a revival of an earlier reaction, fragmentary in character, and functioning—as in planning—as a convenient and simplified substitute for the full action, permitting "manipulation-at-a-distance."* Thus to treat the planning of the future or interpretation of the present, as a type of recollection, is not so paradoxical as it might at first seem, for only where there is *some* basis in experience can we anticipate or interpret at all.

Overt and Implicit Symbolic Activities

Image as "Orientation."—In one respect an image is an "orientation." Just as we may extend a finger and look toward an outer object, so in thought our organism is "pointed" toward the imaged event. The shifts in tonus or posture may be of a minimal character, defying all but the most delicate instruments, or—if the brain psychologist is correct—there may be a purely neural physiological substrate, but the "reference" or "pointing" is apparent.

Similarly, words point to the objects which they name. They stand for, or call our attention to, such objects. In common with implicit trains of pictographic images, our speech—whether overt or implicit—has this same power of representing events, and we employ both types constantly in our thoughtful planning and problem solving. In fact, when we center our attention upon this representative function, the distinction between implicit and overt activities, between thought and action (in these senses), does not appear to be the fundamental fact. What does it matter whether I plan tomorrow's lecture by talking aloud, by muttering or whispering to myself, by jotting notes, or by auditory or motor imagery of what I shall say? Practical considerations may make the first process inappropriate, the familiar character of the material may make the notes unnecessary; but either type of reaction serves the

same purpose. If the material is sufficiently difficult, and the class hour so short that careful planning is necessary, then I shall at least attempt an outline. Shall I then divide this case of planning into two phases: thought (images, perceptions) and action (writing movements)? My movements in writing have as much "forward reference" as the responses which immediately precede and follow, and the motionless lines on the page are a necessary factor in evoking my subsequent rearrangement, cutting, revision of the outline. In fact, if the material is at all complex, they will hold my thought for me and permit me to see the lecture as a whole, in a way that no "image" can do. The entire cycle is so intimately bound together, with one response leading into the next, that it seems impossible (and fruitless) to attempt to split it into fragments.

Three Ways of Thinking.—We might picture the thinking of the chemist as occurring on three different levels:

1. He may rehearse the stages of his experiment internally, subvocally, and, through his familiarity with formulas and chemical reactions in general, forecast the results of his projected action. If the reactions are fairly simple and the materials familiar, whole procedures may be symbolized in a single phrase (subvocal). Items which would be necessary for the novice may not appear at all.

2. He may resort to his notebook and pencil, writing out his equations, balancing them, and computing exact quantities of his materials. With valuable materials he may wish to check his results, or compare possible alternative procedures. Here the activities are overt, a record is made which others may see; but there is the same reference to another final procedure.

3. Beyond this stage he may advance to the construction of a model. If he is the engineer for a large corporation which is projecting a new process of commercial manufacture of a compound he has isolated, his employers will want to see his theoretical results tested under conditions which more closely approximate those of the industrial plant. He may build a small blast furnace, vats for acid treatment, in an endeavor to anticipate practical problems which may later arise. The experimental, tentative, and reversible character of the process and its continual forward reference give it all the earmarks of thought.

So the mathematician may do his thinking in terms of imagery and inner speech, or with symbols on blackboard or paper, with compass, ruler, adding machines; the architect will need his drawing board, T square, slide rule, and his "Strength of Materials" handbook. It is obvious that if the thinking is to go beyond a very simple level it will have to employ more than visualization and inner speech. Some symbolic, representative scheme to hold each stage

of thought firmly as exploration advances or some representation of the problem situation toward which thinking is directed[1] is necessary.

The *thought-provoking* situation is typically one in which we are abundantly motivated and at the same time somehow inhibited, or held in check. We may be held in check by the sheer immensity of the task confronting us, by our ignorance and incapacities. Thus, a society confronted by the problems of unemployment and threats of war—problems too large for any individual and too complex for any simple political solution—grows thoughtful and turns to discussions of economics and the theory of the state, problems which previously did not interest any great number of its citizens. Confronted as we are by difficulties—baffled, thwarted, puzzled, uncertain—and driven by urgent necessity, by floods of stimuli which must be dealt with, we are forced to cut and try, ponder, reflect, think our way out of the difficulty. To be sure, this much of the description applies equally well to the struggles of Thorndike's cats and the meditations of the philosopher. The difference would seem to lie in the philosopher's ability to substitute the symbolic, tentative, representative image (or act) for the more overt, final, and possibly disastrous action.

Thinking as Experimental Action.—We should not forget this element of "inhibition." It is when "something gives us pause" that we stop to think. Where the consequences of action are unknown, and especially where they may be disastrous, we move cautiously. The easy flow of our actions is interrupted, inhibited. We prefer not to commit ourselves finally, and we endeavor to project the act in some symbolic, experimental procedure. Our explorations are capable of recall, are reversible—in short—and not final. Like the feelers put out by the Department of State, the private conversations between representatives of nations, our experimental attempts at solution can be taken back with safety, in case they meet with rebuff. Where, as in conversations with our best friends, we know that the basis of friendship is so firmly established that chance blunders will not give offense, we "think aloud"; but

[1] The emphasis upon the functional aspect of these processes suggests that the distinction between thought and action is more nearly that between means and end, between tentative, experimental, and reversible stages and the later stage of final, irrevocable action. Perhaps in this sense the building of the model furnace is final action, with reference to the earlier construction of its plans; at the same time, it is an experimental, tentative, and reversible affair in comparison with the later construction of the new wing of the factory.

only to the extent where blunders are not vital. Even with our best friends there may be questions which must be reserved for a more implicit type of treatment. So it is that where there is a combination of uncertainty and risk we are driven to experimentation and thought. The amateur craftsman will stop to lay out his plans for the panel to his radio cabinet before he finally drills the holes; the dressmaker will construct a pattern before slashing into the costly materials. Whether we speak of images, an internal conversation, the overt conversation of the diplomats, the layout of plans, or the construction of the model blast furnace, it would seem that we are dealing with a functionally uniform type of action. The difference in the degree to which the musculature and a variety of tools are involved does not seem particularly vital.

The Matrix and Locus of Thought

A description of thinking which stops at the confines of the biological organism is incomplete. Just as a living organism is inconceivable without a life-supporting environment, so thought—in common with the rest of behavior—requires an external environment or matrix to initiate and support its action. Sometimes thought has been described as though occurring in a biological and social vacuum, as though it consisted in a train of disembodied ideas, each immaculately conceived and dwelling in an isolated consciousness. Already we have departed from this view in the functional description outlined in the preceding section, for in incorporating the tools of thought, the "problem situation," and overt as well as implicit experimentation, we have left the confines of the biological unit.

Above all, our thinking bears the imprint of the social matrix. Experimental studies[1] have shown, for example, that the mere physical presence of others alters the course of our thinking. Mildly facilitated, our productions increase in quantity and at the same time "flatten out" and are conventionalized. Though we keep our thoughts to ourselves, they are in a measure directed by (and toward) those who are present.

The very vocabulary with which we think is like a museum collection of hand-forged tools slowly accumulated by generations of

[1] Cf. *e.g.*, Allport, Floyd, discussion in his *Social psychology*, p. 273. Boston: Houghton, 1924.

inventors. Acquired with little effort on our part, our words (and the concepts which they symbolize) serve as instruments of analysis with which we are able to break up our environment into bits that we can handle. And because the use of these tools is socially enforced, since communication is so difficult where we are wordless, our thought itself becomes shaped by its instruments. In addition to the word units there are those word patterns—ranging from wise saws and maxims, which provide platitudinous recipes for everyday conduct, to the classics of literature and philosophy. Is it a question of honesty? That is, of course, the "best policy." The "stitch in time" is all the more imperative because of the verbal warning our speech habits provide. To acquire an acquaintance with a culture is to acquire a cast of thought.

And there are arrangements of a more tangible sort, equally important in determining the content of our thought. Those who have gone before us have left their imprint in the form of man-made objects and institutions. There is the whole machinery of scientific research: laboratories, apparatus, and bound volumes of "recipes." And there are the cities, transportation systems, printing presses, theaters, and churches, and—basic to our civilization—the machines and factories which produce our homes, clothing, foods—even our ideas.

The cultural framework within which we, as individuals, are embedded supplies more than content; it is a dynamic affair, an affair of stresses and strains. For example, our membership in a social-economic class provides us with a "slant" upon the world, a perspective, a philosophy; and this class bias provides an orientation, a trend to our thinking which many express and few fully understand. Most of the members of a "decadent" social group express a characteristic cynicism, but only the most reflective will know the causes of their mental outlook.

In a sense, therefore, the psychologist who confines his attention exclusively to the biological individual standing before him—to receptors, brain paths, effectors—or who hopes to unravel the forces determining his thoughts through a study of his own inner consciousness is doomed to disappointment and failure. Neither the content nor the course of thought can be understood apart from its context or matrix. There are no physical, physiological, or biological concepts from which one could derive the content of a single individual mind. And fully to describe and understand the "contemporary

mind" one would have to know contemporary culture, and more—the historic roots which lie buried in the past.

At the same time the psychologist must discover how these cultural forces affect the individual. Although you and I are both products of our culture, there are very evident differences between the products. In the individual the forces find expression. It is *I* (and you) who do the thinking.

This, then, is the psychologist's problem: to describe these tentative, symbolic, representational adjustments within the individual, keeping in mind that, though we are prone to locate the processes within an individual, there is always a wider matrix to be considered. It is trite to say again that man is a social animal; but at no point is the reminder more needed; for thinking—by its very nature—transcends the individual. Thought has a "reference" and arises within a matrix; both its origin and its goal carry our discussion beyond the confines of the organism.

Mechanical Analogies and Thinking

"Traces" and Their Reactivation.—Nearly all views of learning, perceiving, and thinking advance the notion of some type of "trace" in the nervous system. Established by training, by the imprint of external events upon the plastic organism, these traces form the basis of later recall. Commonly these traces are thought of as some type of change in neural tissue and are usually referred to the synaptic junctions of the central nervous system. Like a wax record of a spoken phrase formed by modern sound-recording machinery, which can be played over again and again, giving forth the same pattern of sound, this neural engram is thought of as the physiological basis of memory. Recurring images appear in the stream of consciousness because the neural grooves impressed at an earlier time provide channels of least resistance for entering impulses. And if some things persist longer it is because they have made a deeper set of cortical grooves. Repetition, like the process of erosion, wears the channels deeper; and forgetting, conversely, may be viewed as a fading out of the impression or its obliteration by subsequent neural events.

Under this view the process of habit formation is one of establishing such engrams; retention is based upon their persistence; and recall and recognition involve their reactivation. If a present, outer event reminds us of the past or provokes a train of thought, it will

be because of association bonds, old grooves which link together the succeeding conscious and behavioral elements. The elements which are called up have, in the interval since their establishment, simply rested in storage. If our recall is incomplete, we may attribute this to the fading of the record, an inadequate first impression, or to momentary conditions which prevent the free operation of the traces.

It is impossible, in the present state of our knowledge, to secure any support for this simple mechanical view of things from neurological studies. In the first place, we have discovered no method of studying the neural trace directly; in the second place, the indirect evidence from studies of learning and recall seriously calls the whole notion into question.

Reception Is Not Altogether a Passive Affair:—Outer events do not make their impression upon any waxlike substance. On the contrary, they evoke active responses. The perceiving and attending individual is busy selecting, evaluating, remolding his environment; and when he is most definitely trying to take it in he is least of all a passive recording machine. The youth's attitude toward the lady of his choice, the conservative's attitude toward social reformers, a mother's attitude toward her son, all are obviously charged with emotion and warped by bias. And this same subjective, intentional, selective element is present in all reception.

Even the conventional laboratory experiment in memorizing reveals this factor, although the materials are purposely made as abstract and colorless as possible. We prepare, for example, a list of "nonsense" syllables, building them from pairs of consonants with an intervening vowel—BAF, NIM, ZUB, WOC, KAL, LEK, etc. From this list we eliminate BAD, BAN, BAT, etc., because these have meaning and arouse such widely different responses in different individuals that, if we are interested in studying the external conditions which govern efficient memorizing, these uncontrolled and unstandardized elements will invalidate all our comparisons. We might wish, for instance, to compare the effects of practice when a list is presented as a whole with practice on a comparable list which is memorized in parts. If, however, the lists contain meaningful material (and the life, background, habits, interests of our subjects are unknown), we cannot tell whether one list is equal to another or not, and differences in learning rates cannot be attributed to the methods used.

But even with the most carefully chosen materials the selective factor will emerge. Suppose, for example, that the syllables are presented to our subject in pairs, together with the instruction to associate them, and with the warning that tests will be made later by presenting the first member of the pair alone. Now, although we expose each syllable for a fixed exposure time and equate both exposures and intervening spaces, under such instructions the subject is far from passive and the bonds which are formed are a function of this attitude. If we show:

BAF.... .. . .NIM
ZUB.. ...   . .WOC
KAL.... .. .. LEK

exposing but a syllable at a time, there is nothing in the objective arrangement of the syllables that should prevent an association between NIM and ZUB; but, if we ask our subject for such associations, he will, in all probability, regard the request as unreasonable. That was not the association we had asked for. And if we had given our subject no instructions whatever, and if he had been totally unfamiliar with the queer performances of psychological laboratories, in all probability he would have formed no syllable associations at all (although he would have been able to report, in a general way, on what had taken place).

The significance of this for memory and thinking is very great. If it is true that we can revive only the responses made in the first instance, and if the original response is not a passive reception of an external order—but instead an imposed construction, highly selective in character, then we should not treat the materials of our thought as a photographic replica of external reality. Our thoughts are at best "our version" of that reality, and unless we are constantly critical of our "constructions" we shall make the mistake of referring what is of subjective origin to outer causes. We shall then resemble those who suffer from hallucinations even though our mistaken "reference" is not so grave and not so easily recognized.

The Eidetic Image: Imagery Types

Galton's Study of Imagery.—The work of E. R. Jaensch[1] and his pupils at Marburg served to call attention to a type of imagery which at first glance seems to belong to a distinct category and to

[1] Jaensch, E. R. *Eidetic imagery.* New York: Harcourt, 1930.

escape many of the shortcomings of ordinary recall. Differences in imagery had long been known. Asking his subjects to think of the breakfast table, and to "consider carefully the picture that rises before your mind's eye," Sir Francis Galton (1880) discovered, to his surprise, that the majority of his acquaintances in scientific work had no notion whatever of what he sought and accused him of romancing. They asserted that of course they knew and could repeat what was on the table, but as for "images" and "the mind's eye," these were mere figures of speech and not to be taken literally. But others understood the question perfectly and were not only positive as to the vividness of their experiences, but could recite most minute details. So few scientists possessed the faculty that Galton concluded:

> . . . an over ready perception of sharp mental pictures is antagonistic to the acquirement of habits of highly-generalized and abstract thought, especially when the steps of reasoning are carried on by words as symbols, and that if the faculty of seeing the pictures was ever possessed by men who think hard, it is very apt to be lost by disuse.[1]

The power of visualizing he found to be higher in women and boys than in men, and he was inclined to believe that "language and book learning tend to dull it."

Other investigators have described auditory, motor (kinesthetic), tactile, olfactory types of imagery, although all agree that the visual is the most common. In a recent study by Griffitts,[2] 90 per cent of more than a hundred subjects reported visual images as predominant, and no subject was wholly without them. In all probability intensive study of the individuals who seem limited to one modality would reveal the presence of other forms. We have no choice, however, but to accept the subject's word for it, and upon this basis most of us are of the predominantly visual type; a few seem confined mainly to auditory images; and some report only kinesthetic images. The verbal type, common among those who work with abstract, verbal material, may, in turn, be divided into those who "hear," "see," or "feel" the words, and in the last group are those who report incipient speech movements in recall.

[1] Galton, F. Inquiries into human faculty and its development, p. 88. New York: Dutton, 1908. Reprinted by permission of the publishers.

[2] Griffitts, C. H. Individual differences in imagery. *Psychol. Monogr.*, 1927, 37, No. 3, 91.

Galton was curious to know where his subjects "localized" their images, and in response to his query most subjects reported that the images were not definitely placed. A few thought they were "in front of the eye"; others placed them at a distance corresponding with the position of the imaged object. Rarely, the subject insisted that the image could be projected upon a piece of paper and was so "objective" in character that its outline could be traced with a pencil. Galton writes:

> I have many cases of persons mentally reading off scores when playing the pianoforte, or manuscript when they are making speeches. One statesman has assured me that a certain hesitation in utterance which he has at times is due to his being plagued by the image of his manuscript speech with its original erasures and corrections. He cannot lay the ghost, and he puzzles in trying to decipher it.[1]

Eidetic Imagery.—It is with such vivid images of almost hallucinatory clearness that the Marburg group have been concerned. Approximately 60 per cent of all school children of the district were found to have these "eidetic" images and could project them upon a surface before them. Gordon Allport, repeating Jaensch's observations, found that 50 per cent of the eleven-year-olds examined in Cambridge had them. These images have the vividness and substantiality of a visual afterimage, and like the latter may move with the eye. They are far more persistent than the afterimage, however, and may be revived voluntarily, hours, days, and even months after a few seconds' exposure. On occasion they may be obsessive in character, recurring spontaneously, and—as in the case of childhood fears—approach hallucinations.

By far the most striking characteristic of the eidetic image is its richness in detail. Exposing pictures to eleven-year-olds for 35 seconds, the experimenter[2] then tested their "reproductions," asking them to report what they saw in the image, and pressing for details merely by asking them to describe certain features more closely. The images appeared as though "projected" upon a gray background placed at normal reading distance, and they possessed a richness in detail greater than either visual afterimage or memory image commonly shows. The subjects seemed to be able to "read" the items from the image, frequently adding to and occasionally correcting

[1] Galton, *op. cit.*, p. 96. Reprinted by permission of the publishers.
[2] Allport, G. W. Eidetic imagery. *Brit. J. Psychol.*, 1924, 15, 99–120.

what had previously been reported from memory. Details such as the following were reported: the precise number of buttons on a pedestrian's jacket, the letters composing a word in a "foreign language on a poster in the background," the length and direction of the lines of shading in a stretch of roadway, the number of whiskers on a cat's lip, the correct spelling of the word "*Gartenwirtschaft*," which appeared in the pictures in small letters over the door.

FIG. 97.—Picture used by Allport in studying eidetic imagery in school children. Although the picture was exposed for but 35 sec., children showing eidetic imagery could, in some cases, reproduce the long German word over the entrance of the building. (*From Boring, Langfeld, and Weld. Psychology, p.* 362. *New York: Wiley*, 1935. *By permission of the publishers.*)

Although in the last case the child had been preoccupied with other interesting items, likewise described, and the entire exposure had lasted but 35 seconds, three out of 30 Eidetiker spelled the word correctly, and seven had no more than two errors.

These facts are sufficient to correct and qualify our first view of the imaging process. The selective factors (intention, interest, attention, familiarity) are not so powerful as to exclude all details not directly sought, at least in these exceptional subjects. While one cannot assert precisely what the interests and intentions of Allport's subject's were, some of the items reported were certainly

unintelligible, and the letters of a word in a foreign language, appearing—in this case—on a poster "in the background," would certainly seem to lie outside the child's range of "interests." In this richness of detail the imagery of the most pronounced Eidetiker certainly approaches a kind of photographic memory.

But Jaensch, Allport, Klüver, and others who have studied this type assure us that the projections are far from photographic. When, for example, the eidetic test is preceded by the more common type of imagery and recall, the eidetic image reproduces the errors of the memory image. The vividness and apparent objectivity of the eidetic image is no proof of accuracy. There are alterations, transpositions, and reversals. Parts of the picture which proved more interesting to the subjects are likely to be "seen," others tend to be weak or fail to appear. Fifty per cent of Allport's subjects failed to get an eidetic image of an ordinary house, whereas all succeeded when a picture of a monkey was used. There are also additions, not present in the model, and these are seen as vividly as the reproduced portions. The alterations, Allport notes, are "consistent with the child's own experience"; he does not add the atypical and the "impossible."

Many of the pictures portrayed action, and in the image the action was continued, completed. (How far we have come from the conception of static brain traces!) On occasion this was produced voluntarily: thus a carriage was made to drive down a street and turn a corner. Klüver, in a similar study,[1] used animal pictures, and both voluntary and spontaneous movements were reported. When a picture showing a donkey standing some distance from a manger was used, the donkey moved to the manger, moved his ears, bent his neck, ate, etc. Suggestions from the experimenter (*e.g.*, "The donkey is hungry!") sometimes served to set in motion a series of changes which surprised the subjects. On one occasion when Klüver suggested that the subject try to move the donkey, the subject reported, "I made no conscious effort to bring them together. The minute you finished your sentence the donkey flashed to the manger. I think my mind did that unconsciously."

Why should some subjects have such vivid imagery, while others are scarcely able to understand what imagery is like? Why should it be so much more prevalent among children, apparently diminishing

[1] Klüver, H. An experimental study of the eidetic type. *Genet. Psychol. Monogr.*, 1926, 1, 71–230.

after adolescence? Why should it be more prevalent (as Jaensch asserts) in the school population of the *Arbeitschule* than in other schools? Or why should it be found more frequently among mental defectives? The answers to these questions are of such speculative nature that extended discussion in this place is scarcely profitable. Among the causes which have been proposed and discussed are: constitutional and inherited differences, differences in glandular function (thyroid, parathyroid, gonads), differences in calcium metabolism, pedagogical methods. Some would make of the eidetic image a kind of primitive and undifferentiated process out of which our perceptions and memory images are later differentiated, thus regarding them as a necessary step in development. Under this view the growing tendency toward analysis, the developing interests and drives, the accumulating experiences, all serve to split up, distort, repress the eidetic process. Eidetic imagery among adults is clearly an anomaly. For the child such a process may serve a very useful purpose, for important events which are worthy of continued inspection occur in too-rapid succession. The eidetic images provide an opportunity for more extended exploration, and it is possible that the child's more limited "frame of reference" has less power of distorting that which is presented. He is less prejudiced; his interests are, in a sense, more catholic—or generalized. Similarly his growing concern with the real world (as evidenced, for example, by his clearer recognition of the differences between truth and falsity, between real and imaginary events), together with his increasing reliance upon more abstract (verbal) tools, all conspire to curtail the full development of such image processes, and in the end the "gift" may atrophy from disuse.

For all its richness in detail, the eidetic image is neither photographic nor static.[1] It moves on its background, and changes with

[1] Klüver and others have reported one interesting item. When afterimages are projected upon surfaces at varying distances from the eyes, their size is found to be proportional to the distance of the surface (except at extremes). The eidetic image, on the contrary, while showing some slight effect of distance, is roughly constant at the positions tested (25, 50, and 100 cm.). In the case of the afterimage the explanation can be made in terms of the size of the visual angle. Since the phenomenon originates in the retinal aftereffects of stimulation, the size of the retinal patch is the determiner of the angle, and with a constant angle the projection plane will show increasing areas at increasing distances. The relative constancy of the eidetic area is one fact demonstrating the nonretinal origin of the phenomenon. Although the image may move with changes in

time. The longer the interval between impression and recall the greater the likelihood of distortion and change. Even in this most vivid and detailed type of imagery, there are additions, transpositions, reversals, and the role of selective interests and a background of experience is once more portrayed.

Memory vs. Memorizing

The concept of habit as a fixed pattern of action dependent upon neural grooves, pathways of lowered resistance, seems to fit many of our actions. The lessons we "learn by heart" so as to recite them parrot-wise, the list of prepositions which take the dative case, the telephone numbers of our friends, our habits of dressing, eating, typing, dancing—all of these routine and automatic acts seem to fit the simple mechanical analogy.[1] Their very usefulness depends upon their stereotyped and automatic character, and though minor variations unquestionably exist, the pattern is consistent and accurate enough for our purposes.

But while habit may be, as James[2] describes it, our "most precious conservative agent," and while it may be the great stabilizing factor in our lives ("the enormous flywheel of society") it must not be offered as the sole insight into the nature of thinking. In fact, the automatic habit is a rather special case, depending upon special

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fixation, its localization and dimensions clearly depend upon a wide postural matrix.

[1] They will, however, if closely scrutinized, show a variability from performance to performance which violates the view under discussion. Even the perfectly automatized maze habit of the white rat shows variations from trial to trial. The detailed sequence of movements is never twice the same, any more than the gyrations of a couple dancing on a crowded dance floor involve a set pattern of muscular contractions. And the most stereotyped instances of insect activity, once described as chain reflexes, show a plasticity, an adaptability to a changing environmental matrix. Thus the web spinning of the spider, offered by Major Hingston (*Instinct and Intelligence*) as an example of the blindness and fixity of instinct, must be adapted to the conformation of the surfaces upon which the web is anchored. The nest has to "fit into" the crotch of the tree, the movements of the dance have to fit into the changing openings on the crowded floor, the voice of the speaker is adjusted to the distance of his audience even when he recites a memorized speech, etc. Even the most stereotyped acts of bird, insect, human, are able to adjust themselves to a changing matrix.

[2] James, William. *Principles of psychology*, Vol. 1, p. 121. New York: Holt, 1890.

conditions, and in many respects it is the very opposite of what we call "thoughtful" behavior.

In the memory experiment we commonly work, explicitly and intentionally, toward accurate and routine recall. We expose the nonsense syllables under uniform conditions, again and again, until a stable organization is set up, perhaps measuring the number of trials until a preestablished criterion of accuracy is achieved. If we fail we are prompted, if we commit errors we must try again. Until our anticipations and reproductions check with the external model our task is incomplete. Given sufficient time, unchanging motivation, opportunities for correction and reformulation, we do develop stereotyped patterns which persist for a considerable period, and although they are in no sense the mirror image of reality, they meet all the demands of practical necessity.

But life is not an external recurrence. We grow, develop, and decline. The organism which returns a second time is not the same; it has acquired new purposes and brings new postures. The habits which may serve the adolescent fail to meet the test of an adult world; in fact, the adolescent is no more, and this very fact has altered the appearance of the external scene, the values of the stimuli, etc. And the changing sequences of events which make up life outside the laboratory give us little opportunity to repeat, revise, reformulate, and automatize. It is in vain that an oldster sighs, "If I could only live that all over again." Neither the world nor the individual returns repeatedly to the starting place until the perfect (and automatic) life is constructed. We "make a stab" at the passing moment, and out of our errors we compound new ones, until—if we and the world are stable enough—a passable adjustment is achieved. The size of that segment of our lives devoted to habit and routine is thus a measure of the relative stability of our world.

Thus it is that concepts drawn from laboratory memorizing experiments and routine habits can really cope with but a small portion of human experience. The bulk of our "stored experience" consists of much less stable organizations, and most of it lies below the level of any conscious reinstatement.

We need, therefore, to study the incomplete habit, the case of partial recall, the errors as well as the successes, the unstable and changing situation, as well as those stereotyped successes produced under rigidly controlled laboratory conditions, if we would discover

typical human responses—particularly if we are interested in thoughtful, imaginative, rational processes.

One of the most significant studies of this type in recent years is that of F. C. Bartlett,[1] and it will be worth our while to consider some of his findings. His methods of procedure, the materials used, the tasks assigned his subjects, all come much closer to living situations than did the earlier conventional experiments (*e.g.*, those of Ebbinghaus with nonsense syllables) and are therefore germane to our interests.

Transformation of Perceived Material

At the Moment of Perception.—Let us first turn to the experiments which deal with the process of perceiving itself. Complex meaningful material was briefly exposed by means of a tachistoscope, and the subjects were requested to write out a description immediately. Although repeated exposures were given on request (as many as 30 to 40 times), the exposures were too brief (1/15 to 1/4 sec.) to allow extensive inspection and exploration. Working thus at the margin where perception is barely possible serves to exaggerate all those factors which transform and distort the process. Thus, a certain picture ("Hubert and Arthur" by W. F. Yeames) was interpreted by different subjects, according to their interests, attitudes, experiences: "a little girl saying her prayers on the other side of her mother's knee," "two people wrestling," "Othello and Desdemona," "The Woman Taken in Adultery," "Charles the First and Henrietta." In some instances the name, recognition, interpretation rose automatically, and at other times there was a more intentional and conscious search for analogical material. But whether the subject was conscious of this frame of reference in the form of images or of some definite recollection of where he had seen the picture before, etc., it was clear that the processes of perceiving, judging, inferring, remembering, constructing, and valuing were all clearly mingled in the subjects' reports.

And, as in the case of the Eidetiker whose images are distorted by a previous error in recall, the perceiving subjects *see* a white apron, a kneeling girl, wrestling men, a pillar, etc., importing liberally from their own stock of memories, shaping the "perceived object" according to a form or recipe. Once a name or formula has been assigned, it is almost impossible to see the material in any other

[1] Bartlett, F. C. *Remembering.* New York: Macmillan, 1932.

form. Thus, the first exposure of a picture ("Margate Lifeboat on the Slips") reminded a subject of his home, and after eighteen exposures he said: "It is no use going on. All the time I am getting a suggestion of the docks at home. And they are what I see, not the picture in front of me."[1]

Thus the process of transformation begins at the moment of perception. Some dominant feature catches our eye, a name (or image, or formula) flashes out of the past, dominant interests provide a trend to our interpretations, and something that is highly individual emerges.

The Effect of Delay.—The moment delay is introduced, the transforming process is intensified. It is possible, Bartlett thinks, that the organizing framework becomes confused with the presented material. To take an example from the field of psychology itself, a student reading a report of an ablation experiment, and classifying it as similar to one of Lashley's, might find on checking his attempted recall later that his perfectly vivid recollection of certain items was inaccurate and that items in the remembered structure had been transposed bodily from Lashley's account. Briefly, *there is a tendency to distort remembered material in the direction of a frame of reference.* Immediately after exposure the "object" and the classifying response may be clearly distinguished, but as time goes on the boundary between the two breaks down and the more stable structure triumphs.

Again and again one gains the impression that what is recalled is a *construction.* Some dominant impression, some organizing idea, some vague impression, may be all that the subject has to start with; but as he struggles to get back more of the desired material a very definite image may appear, so vivid that it seems to bear the sign and seal of truth and accuracy. But alas for the visualizer:

> In their methods of work all the strong and persistent visualizers were rapid, and rather prone to be confident and optimistic about the accuracy of their reproductions. Their results showed every variety of change possible, with no particular predominance, so far as the picture-signs go, of any one type of transformation. The proneness towards changing the originals increased rapidly with lapse of time.[2]

[1] *Ibid.*, p. 30.

[2] *Ibid.*, p. 111. Reprinted by permission of The Macmillan Company, publishers.

Thus, one of Bartlett's subjects, recalling the face on a picture postcard, originally held in the hand and studied for ten seconds, is very positive in her emphasis of certain features (a square face, serious, determined looking). On termination of her report the experimenter showed her the card.

She was amazed, and thought at first that I had substituted a new card. Her Captain, she said, was very much more serious; his mouth was firmer, his chin more prominent, his face more square.[1]

Conventionalization.—We frequently forget the supporting matrix within which the recall process operates. Centering our attention upon the cue which is presented we think of the response as mediated by narrowly defined conduction paths in the nervous system. But every word has many associations, every figure many meanings. What selects the one?

If we propose the attention process, we are, in effect, using the fact of selection to explain selection. Behind the name, attention, lie the conditions which operate. There are the experimenter, the instructions, the presented cue, the whole laboratory setting, and my background of training which has fitted me to participate in experimental procedure. And this background of training has established a few stable habits, general trends to my thought. The daily impact of a cultural medium, with its institutions, its turns of speech, conventional designs, now shows itself in my very posture, expectancies, and just as in perception this postural matrix operates in favor of "probable" things being perceived, so in this moment of recall my reproductions will be pulled in the direction of the conventional, the stereotyped. The fragments which rise quickly (the dominant, vivid, interesting, familiar parts of the figure I saw) will be shaped into the "usual," conventional, probable whole.

Striking evidence of this tendency, and of the importance of social factors, appear in what Bartlett calls the *method of serial reproduction*. In this procedure the reproduction of subject *A* is used as a model for *B*, *B*'s reproduction serves as a model for *C*, etc. By the time a few subjects have served as "filters" for the material, it has assumed an unrecognizable form. The first reproduction of a passage from Wallace's *Darwinism* is fairly accurate, but by the eleventh subject it has become unrecognizable. The

[1] *Ibid.*, p. 54. Reprinted by permission of The Macmillan Company, publishers.

argument is reversed, the one proper name retained is altered, and a bit of popular folklore is inserted.

Reproduction 1.

The Modification of Species

The objection put forward by Mr. Gulick, that isolation is not a sufficient cause for the modification of species, deserves attention. For there are certain things which, if this were a *vera causa*, are not as we should have expected them to be. In Ireland we have an excellent test-case. We find there mammals, reptiles and molluscs like those in this country, yet it was separated from Britain during the glacial period for many thousands of years.

Even if modification of species were a result of isolation . . .

Reproduction 11.

Mr. Garlick says that isolation is the result of modification. This is the reason that snakes and reptiles are not found in Ireland.[1]

It should be added that each subject was permitted to read the material through twice at his normal reading rate, and reproduction followed in from 15 to 30 min. Although the subjects were untrained in the biological sciences, several of them had made some study of logic.

An American Indian folk tale called "The War of the Ghosts" retained its title to the end, but lost its ghosts and all other supernatural elements. More striking than the omissions, rationalizations, transpositions, is the drastic revision of the tale to fit a British model. Clearly, material that is imported from another culture will either fail to circulate at all or else will be revised to fit prevailing conceptions. Once an imported element is omitted, it is gone forever, for it will never occur to the others who relay the pattern. Bartlett's study reveals the factors which must operate in producing the folk tale, myth, rumor, and deserves a place in the portfolio of every student of primitive culture. As a matter of fact, such a study might well cause the student of psychology to do some reflecting, since the very textbook which he reads is a reproduction often many times removed from that source (human behavior) to which it professedly refers.

More vividly than words, the following pairs of drawings, representing the beginning and end of a series, illustrate the process of

[1] *Ibid.*, pp. 166–167. Reprinted by permission of The Macmillan Company, publishers.

conventionalization in another field. The portrait of a man was stabilized in conventional form by the fifth reproduction, and the Egyptian *mulak* became a cat on the tenth, and remained with little change until the end of the series (eighteenth).

Remembering, Thinking, Imagining.—The evidence which we have examined suggests that there is a great deal of resemblance

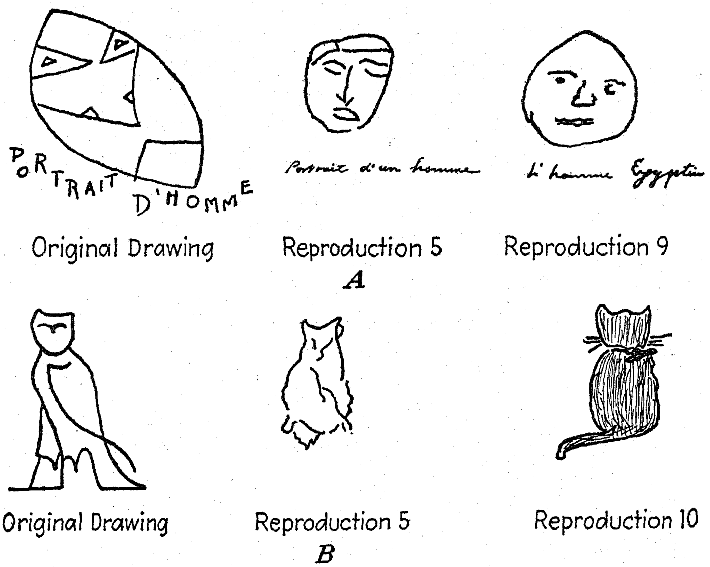

FIG. 98.—Bartlett's figures illustrating the principle of conventionalization. *A*. Sample reproductions of an odd drawing of a human head. Note how the position is "corrected" and the features conventionalized. *B*. An Egyptian "mulak" becomes a cat by the tenth reproduction. (*From F. C. Bartlett. Remembering, pp.* 178–181. *Cambridge University Press*, 1932. *By permission of the publishers.*)

in all the "higher" mental processes. All show a determination by the past, and all show constructions, inventions, transpositions. Even with the special effort and special conditions of the memory experiment, past integrations do not come back unaltered. Stability and stereotyping of behavior require the constant reinforcement and redirection of a stable supporting environment as well as—what is never completely achieved—a stable and unchanging organism.

Once we abandon the simplified mechanical conception of fixed neural traces and consider "remembering" as it actually exists, the distinction between remembering, thinking, and imagining is less a distinction between processes than between situations. Think-

ing (as problem solving) is determined by the past too, but the new situation demands more than a revival of an old integration. Its very newness *forces* a fresh assemblage and configuration of responses. The kaleidoscopic shifts in the environmental field call for readjustment in our ways of dealing with it, and if the new fusion is achieved in terms of symbolic activities (overt or implicit) we speak of thinking. Each stage of the thought process involves remembering, but recall operates under special internal conditions (motive, drive, interest) and under special external factors (the problem situation). Here the distortions, transpositions, etc., are again directed by the present active context.

If there is any valid distinction between thinking and imagining, it is to be found in the type of setting and controls rather than in the process at work. We are likely to describe imagining as a freer, more playful activity, less rigorously controlled by an immediately pressing problem and less bound by a grim external reality. The "figments" of the imagination are, too, more individual, personal, and private; and they have less circulation value among our peers who demand a "reasonable" kind of currency (*i.e.*, descriptions which fit their interests and purposes and meet the test of their experience). But when we meet such a term as "scientific imagination," we can see that our distinctions in usage are as often violated as observed.

In part, the distinction is a question of "reference." We may perceive and think about a present situation; we remember past events; and we may imagine that which has no counterpart in material reality. But in the latter case the *process* is as rigidly determined as any mental process. When we describe our mental construction as "purely imaginary" we indicate that it does not refer to, point out, or indicate any external object which another could share. Only in the field of pathology or perhaps in the imagination of childhood—where the distinction between the imaginary and the real is less sharply drawn—is there ever complete confusion between the two.

Recognition and Recall

Three special cases of remembering deserve a word of comment. When the recall process is most complete we are not only able to reinstate the reaction which the situation requires, but we are able to refer to its origin in space and time. Without for a moment

losing our orientation to present events we recognize our responses as old, familiar, belonging to another context. It is as though the relevant fragment brought along with it a section of its former matrix. Without confusion we maintain a double orientation.

If the linkages between the recalled items and their former matrix are too strong, they will prevent efficient thinking (at least of the directed, problem-solving type). Where each recalled item comes dragging its neighbor, the whole problem-solving process bogs down under the weight of recalled details and the present purpose is lost sight of. We itch with impatience for the garrulous narrator to get on with the story; we would willingly dispense with details. He, on the other hand, is so much absorbed in the past, and so relishes the details, that he has lost sight both of his purpose and of his listeners. He may even be so carried away as to have to pause to ask us, "Now where was I?"

Between the extremes of complete absorption in the present and complete absorption in the past (which may reach the stage of hallucination) our more efficient recall must lie. Highly selective, it discards, inhibits, represses the irrelevant detail; at the same time it is oriented both to the present and to the past, and hence less apt to make blind application of knowledge. When we recognize the source of revived material we are better prepared to evaluate its applicability. Bartlett's subject who recognized that his images came from his own seaside home refused to credit his construction of the tachistoscopic exposure, aware of the improbability of his interpretation.

False Recognition: The "Feeling of Familiarity."—But this ideal and delicately balanced reaction is not always present. We may recognize falsely too, depending upon a vaguely felt "familiarity." This impression of "having been there before" or of "having seen it somewhere" may or may not be true. The prisoner in the line-up at police headquarters may be falsely recognized by the robbery victim, who makes a specific (though false) reference to a past context. Our orientation to the past is thus seen to be as subject to distortion by the present as, in other circumstances, our orientation to the present is distorted by the body of preconceptions, enduring interests, etc., which stem from the past. Where false recognition consists merely in a vague and undefined "feeling" we may describe it as a general and undefined preparatory reaction which the present cues cannot force to completion. We can see the process in action

as a picture is slowly built up before our eyes, out of its elements. Here we may pass through a transition stage where it seems about to mean something, and then there comes the time when the addition of another element arouses an "Aha," and we see what the figure is to be. This period just prior to the full completion is seen, too, when we search for a name or a melody. We may have it almost "at the tip of our tongue" or almost "at the tip of our fingers" and yet be unable to complete the reaction. It is as though a preparatory posture is there, but some inhibitory element (or some lack of supporting stimuli) prevents the completion of the pattern. If, in the case of a name, we try the experiment of jotting down a sequence of our best guesses, we may find that fragments of the correct response have been there for some time before the complete reaction appears. Thus, an initial letter, the correct number of syllables, the rhythm of the naming movements, correct letter sequences, and even symbolic substitutes may be there.

Recall without Recognition.—On the other hand, there are occasions when we reproduce old patterns with great exactness without remembering their setting. Indeed, we may not even recognize them as coming from the past, and our "plagiarism" is quite unconscious. Although the item is demonstrably a replica of what we once saw, read, copied, we have totally forgotten the source, and treat the materials as our own original creation. In part, this splitting of an "idea" (or reaction) from its context may be accomplished by its repeated use in a variety of settings. Perhaps we repeated it, at first, soon after reading it, remembering not only the "idea" but its setting. But if we have found the same idea useful on numerous occasions, it comes finally to belong to none of them, but rather to ourselves. If the later recall situations are not such as repeatedly to demand (and hence reinforce) the "reference" to the source of the idea, experimental extinction will eliminate that section of the configuration, and it will remain merely as an "idea I picked up somewhere" or as something "I always say." In addition, the context may be so foreign and so irrelevant or opposed in character to the present recall situation that, although the idea is revived, its associates are blocked.

Recognizing When Recall Is Incomplete.—Finally, there is the case of recognition without the ability to reproduce. Recognition is an easier process than reproduction, for in the latter case a small cue only is present and we are called upon to reinstate the rest of

the pattern. To recognize a statement from a text is much easier than to reproduce the statement. In recognition the full stimulus pattern is given; all that the subject is required to do is to "place" the stimulus, to "orient" toward the original occasion. In the simple localization experiment our threshold is much lower when we are permitted to explore the surface, for we "recognize" the true spot when we touch near it, although we cannot in the first instance move directly toward it (*i.e.*, with any too great accuracy). So in our attempted recall of a name, our failure does not indicate complete ignorance, for we can readily recognize it when it is correctly given by another and may reject all substitutes, even those which closely resemble it.

"Subliminal" Memories.—There is thus revealed a kind of "knowledge" which cannot be formulated, a kind of thinking with neither words nor images. Although we cannot reinstate the passage we read, we can spot a false item inserted in the material presented to us.

The "stored past" may be insufficient to bring about reproductions, yet it will serve to identify, classify, and orient us toward the present. As in the localization experiment, where we try to locate the previously touched finger tip, the moment our exploring pencil hits the hand area the correction movement arises. What was an insufficient guide for a complete localization may serve to classify the next stimulus and to correct a fumbling adjustment. Although we may not be able to place a tone upon an absolute scale with great accuracy, we find that our "impression" is good enough to enable us to tell whether a subsequent note is above or below it.

There is thus seen to be a kind of "subliminal" memory or thought. Its very nature makes it difficult to study, since it cannot be directly communicated or given full overt expression. That which guides our recall of a name and is subjectively felt as a kind of "now we are getting warm" is altogether too indefinite to put down in laboratory protocol; and there is as yet no process of instrumentation adequate to catch it. Although for the skeptical, who require physiological measurement, these trends, hunches, directional tendencies at the fringe of consciousness may appear to be altogether hypothetical, the facts seem to demand such hypotheses. Moreover, there are special mental states which show that these subliminal trends are more than figments of the scientific imagination.

In terms of our original figure of the "stream of thought," these subliminal trends would constitute the supporting stream itself. Beneath the floating changing images, beneath all that lies within the view of the "mind's eye," there flows an ongoing process which ought to be examined.

Hypnosis

Procedure.—Perhaps the most convincing demonstration of the reality of "subliminal" mental processes is afforded by the phenomena of hypnosis and, in particular, posthypnotic suggestion. The hypnotic state may be roughly described as a dreamy, relaxed condition in which the subject is highly suggestible. There is a wide variety of techniques by means of which the state may be induced, most of them variations of one developed by Bernheim[1] in the latter part of the nineteenth century. All utilize suggestion, fatigue, monotony.

In the usual procedure the subject is seated comfortably, or allowed to recline, and is urged to relax as much as possible. If these precautions are not taken, the subject's discomfort and tense postures may interfere with the suggestions which follow. The subject is then requested to fixate upon some object—the operator's eyes, a coin, or a point of light. If a light is used, it should not be too bright, for eyestrain and profuse lachrymal secretion will form sources of distraction. Likewise, if the rest of the visual field is darkened, or so simplified as to contain few distracting stimuli, it will be easier for the subject to obey instructions. If the fixation point is placed slightly above the natural line of regard, a moderate fatigue of the eye muscles will facilitate the verbal suggestions. Then, quietly, confidently, and somewhat monotonously, the operator offers suggestions of relaxation, sleep. The wording is unimportant, the content alone matters. For example, he may repeat:

Relax. Think of nothing but sleep. Give me your full attention. Listen to my voice, but watch the light. You are tired. Your arms are tired. Your legs are tired. Your whole body is tired, and relaxing. As you watch the light you will find that your eyes are getting heavier, and heavier. Breathe easily, and slowly. Just let yourself go. Now your eyes are closing, slowly closing, tighter and tighter. You can't hold them open any longer.

[1] Bernheim, H. *Suggestive therapeutics.* New York: Putnam, 1889.

You can't lift them. You are going to sleep. Sleep. You are sound asleep. Etc. etc. . . .

The experimenter may, if he chooses, use passes, but apart from a possible suggestion value (depending upon the subject's notions) they are unnecessary. If the movements pass between the subject's eyes and the fixation object, they may initiate eye reflexes, which make the continued regard more difficult, and aid suggestion by giving the subject the notion that he can no longer hold his eyes up to the fixation point. Within from one to ten minutes a good subject will fall into a sleeplike state. He may try, for a few times, to open his eyes (as can be seen from his lifted brows or a flutter of the lids), but eventually his relaxed posture, closed eyes, and steady breathing will indicate that he has succumbed to the suggestion.

Once the subject is "sound asleep" he may be instructed to open his eyes *without waking up*. If this is carried out gradually (*i.e.*, by warning the subject that his eyes will open when you have counted to ten, and then leisurely counting), the subject will open his eyes, staring rather vacantly like a sleepwalker; but he will remain in the hypnotic state.

The Phenomena. 1. *Hallucinations, Anesthesia.*—If now the subject is presented with a playing card, say the king of spades, and is told that it is a picture of President Roosevelt, he will soberly regard it and confess—if asked—that it is a good likeness. If the card is placed in the deck and the pack carefully shuffled, upon request he will pick out the President's picture, selecting the original card. Similarly, if a young man of his acquaintance is introduced to him as an elderly matron, he accepts the suggestion and shows a serious, polite, and deferential bearing. Or if it is suggested that a piece of chalk, placed in his hands, is an extraordinarily heavy piece of metal, too heavy for him to lift, he will struggle with it as though with a great weight.

Negative suggestions are equally efficacious. If he is told that his right hand is insensitive to pain, he will permit a needle to be thrust through the skin and, although blood may be drawn, he will not flinch. The same stimulus applied to the other hand evokes immediate withdrawal and verbal protest. If he is told that one of the persons standing before him has left the group, he will neglect all stimuli coming from this source. He will count the persons present, always omitting this person, and in general will ignore his presence.

2. *Posthypnotic Amnesia.*—When the subject is wakened he is commonly unable to recall any of the events which transpired during the trance state. This is not always the case, however, and persistent quizzing may show at least a hazy knowledge of the hypnotic events. Where the hypnotic sleep is very light and the subject only partially "under," recall may be quite normal. Even when the forgetting seems complete, however, there is retention; for when the subject is again hypnotized he is able to give a full and adequate account of everything which occurred in the former trance state. Thus, it would seem that we are dealing with two memory systems. The system which contains the everyday waking events is readily accessible under hypnosis. (The subject has no difficulty in recalling former events.) The hypnotic system, however, is less available. It is as though the latter system is somehow broader, more inclusive—as though the waking "self" were but a fragment of some larger, submerged whole.

The time consumed during the séance is frequently a cause of surprise to the subject, who may even accuse you of turning his watch ahead. Though two hours may elapse, it seems to him, on waking, that it was but a moment ago that he fell asleep. Though the hypnotic state has cut a deep and broad crevasse into his system of waking memories, he knows this only by inference, for the walls of the crevasse seem joined together, for him. Like a Rip van Winkle, he can only infer how long he slept from the changes which have transpired, and he is inclined to be incredulous. Though not recalled, the events of the trance are not without influence upon the waking state. The subject who was made to believe, under hypnosis, that he was burned by a match is seen to rub his fingers some time after he has awakened. Although he cannot report on any of the trance events, he *behaves as though* he had full knowledge. When he is questioned as to why he rubs the finger, he says that it seems smooth, as if it had been burned, but adds that it doesn't hurt him.[1]

That "memories" are present, though inaccessible so far as verbal reports go, was further demonstrated by a conditioning technique by Scott.[2] Subjects were hypnotized, led into another

[1] Hull, C. L. *Hypnosis and suggestibility*, p. 31. New York: Appleton-Century, 1933.

[2] Scott, H. D. Hypnosis and the conditioned reflex. *J. gen. Psychol.*, 1930, 4, 113–130

room and conditioned (buzzer shock), returned to the first room and wakened. They had no recollection of their special training. Nevertheless, when they were returned to the apparatus and the buzzer stimulus was given, the effect of the training was apparent: the conditioned reflex operated.

3. *Posthypnotic Suggestion.*—If, during hypnosis, the subject is told that after he awakens, at a specified time (or signal), he will carry out a certain task (for example, winding a clock), in spite of the subject's professed ignorance of everything that has happened while he was asleep, the act is carried out as suggested. If we ask him, "Why are you winding the clock?" he is likely to treat the question as an absurd one, or he says that it "just occurred to him," or that it is simply a matter of not wanting the timepiece to run down. He treats the idea as his own, giving it a rationalization so as to render it plausible, fitting, etc. The posthypnotic phenomena may also include the absurd hallucinations of the state itself. Thus, a subject who was assured that on waking he would feel cold promptly gave an expressive shiver and called for his coat, although the experiment was being conducted in midsummer with the temperature of the room in the nineties. Although freely perspiring and fully awake, the suggestion was fulfilled.

Two recent experimental studies[1] have presented measurements of the persistence of such effects. Both show a decline in the strength of the tendency, more rapid at first than later. In Patten's study it is still in force at the end of the thirty-third day, and in Kellogg's study it is active at the end of the second month. Moll quotes work of Liégeois and Liébault showing that a suggestion was carried out (for the first time) after a lapse of a year, and reports an observation of his own indicating execution of an assigned task at the end of four months (with no intervening hint to the subject).[2]

4. *Hypermnesia.*—In spite of the marked suggestibility of the subject under hypnosis, it is apparent that there are definite limits beyond which he cannot go. The musically untrained subject is not made into a skilled performer merely by suggesting the fact: hypnosis and suggestion offer no new pedagogy. Nor can he acquire

[1] Kellogg, E. R. Duration of the effects of post-hypnotic suggestion. *J. exp. Psychol.*, 1929, 12, 502–514.

Patten, E. F. The duration of post-hypnotic suggestion. *J. abnorm. (soc.) Psychol.*, 1930, 25, 319–334.

[2] Moll, A. *Hypnotism*, 4th ed., p. 174. New York: Scribner.

new material at any greater rate. The only reactions which the words of the operator can "tap" are those already within the equipment of the individual. But there are many facts which indicate that past experience is peculiarly accessible in the hypnotic state. Thus, Moll writes:

> An English officer in Africa was hypnotized . . . and suddenly began to speak a strange language. This turned out to be Welsh, which he had learned as a child, but had forgotten.[1]

A student, twenty-two years of age, while hypnotized, was asked to recall the earliest occasion on which he had appeared in public. He recalled having "spoken a piece" in Sunday school and was told that now he could remember everything. With a little urging he proceeded to recite his verses, swaying to and fro in childish fashion. He recalled the setting, remembered sitting on his father's knee afterward, etc. When awakened he was promptly quizzed as to the occasion and admitted a vague recollection; but as for the "piece," that was gone beyond recall, save for a fragment or two.

Another student, also hypnotized, is given a textbook and told that it is an anthology of compositions recently written by American students, and that one of his own has been included. Then he is instructed to read the selection aloud. He accepts the suggestion somewhat unwillingly, complaining that the type is poor (as well he might for the printed material is quite foreign to the matter suggested), but with some urging he manages to produce a word-perfect account of the first few lines of a "theme" which had been returned to him a week previously. He, too, when wakened seems unable to reproduce the material which was so easily accessible under hypnosis.

Clinical literature abounds in descriptions of amnesias in which large blocks of past experience are no longer available to the waking person. Frequently under hypnosis the "lost" material can be regained, and under favorable conditions successfully integrated with the system of waking memories. William James tells of a certain Rev. Ansel Bourne, of Providence, who "disappeared" January 17, 1887, after drawing a sum of money from his bank. On the morning of March 14 a man who for the past two months had been conducting a small confectionery store wakened in Norris-

[1] *Ibid.*, p. 124. Reprinted by permission of the publishers.

town, Pennsylvania, to announce to his neighbor that he was not A. J. Brown—as they supposed, that he knew nothing of shopkeeping, and that he was totally ignorant of how he had left Providence or of any of the subsequent events. His identity was established, but the memories remained inaccessible until 1890 when James induced Bourne to submit to hypnotism, and the hitherto inaccessible events readily came to the surface. Clinical literature abounds in similar instances.

Within recent years there have been a number of experimental studies which give quantitative proof of this same hypermnesia under hypnosis. Stalnaker and Riddle[1] studied both trance and waking recall of the words of verse which had been learned at least one year previously, and of 92 cases of recall 87 showed superior scores for the hypnotic state. In the trance state 4,170 words were reproduced as against a waking recall of 2,711—an advantage for the trance state of 53.4 per cent. Curiously enough, the evidence is equally clear[2] that memory for recently acquired material is not improved under hypnosis.

It should be noted that, although the experimental studies clearly show a superiority in hypnotic recall—and frequently there is a surprising wealth of detail, there is nothing in the experiments to support the generalization that nothing is ever wholly forgotten. There is no evidence, that is, of a "subconscious mind" which acts as a storehouse, preserving intact *everything* we ever experienced or knew. It seems probable, rather, that we are dealing merely with a state in which there is a certain freedom from inhibition, a certain lowering of "vigilance" (like that of the slightly intoxicated person), and that it is this release from inhibition which permits a greater quantity of material to arise.

By far the most important fact for our purposes is the clear demonstration that in our waking life we carry about "memories" which, though present and active, are inaccessible to consciousness. Though, as in Scott's experiment, we cannot report on the conditioning circumstances, the conditioned responses operate when the stimulus is presented. And when, as in posthypnotic suggestion, we carry out what has previously been suggested, we have the illu-

[1] Stalnaker, J. M., and Riddle, E. E. The effects of hypnosis on long delayed recall. *J. gen. Psychol.*, 1932, 6, 429–449.

[2] Chapter 5 of Hull's *Hypnosis and suggestibility* presents a review of this experimental work.

sion that the scheme is our own, or that it is merely one of those "ungovernable" impulses, etc.

The conscious, reportable portion of the stream of thought is thus seen to be incapable of revealing its own laws of motion. The individual can never hope to know himself, fully, by any ritual of introspection or soul searching. Nor can introspective studies, no matter how brilliant their analysis and description of imagery, fully reveal the processes at work in thinking. Behind the pictures which are exposed to the audience there are forces busily engaged in shifting the scenes.

The Freudian Conception of Unconscious Mental Processes

An Analogy: The Mind Viewed as a House.—No modern discussion of subconscious factors in thought and action can neglect the contribution of Sigmund Freud and his school. Condemned by some as muddleheaded, unscientific, obsessed with sex, he is hailed by others as the Newton of psychology. Since his language is almost never that of physiological psychology, and since many of his ideas have never attained more than a figurative (one might almost say allegorical) expression, it will not be amiss to begin our discussion with a figurative résumé of his notions.

The mind of man may be likened to a house. To make the figure fit the facts, we should conceive a rather special type of dwelling, a bungalow with an extremely deep cellar—perhaps with several subcellars. Within this house dwell our ideas—some conscious (and these are on the street level) and some subconscious (in the cellar and subcellars). The master of the house we may call the censor, for he exercises dictatorial control over the ideas, which latter we might describe as his children. The children are of various grades of presentability, and since the censor is continually receiving callers, he is forced to keep these unpresentable ones out of sight. He represses them, that is, sends them to the basement.

We should note, perhaps, that there is nothing abnormal or unhealthy about these basement children. They are unkempt, rather, and their appearance would shock both the master and callers. The basement children are lively enough and their abundant energy creates considerable disturbance in the basement.

Particularly, when too many children are confined to the lower quarters, when the vital energies of the household are too strongly repressed, the house appears upset, the owner distracted.

Some of these basement children (repressed complexes) scarcely ever see the light of day, for if callers are not present, the owner must at least keep his house in order in preparation for possible visitors. Only at night, when the owner is asleep, do they get by the stair door, and even then they succeed by deception—donning strange masks to prevent recognition.

These midnight revels of the basement children will be recognized as a figurative representation of the dream, and when we recall that Freudianism grew out of a recognition of the importance of subconscious factors, we can see why he early turned to an analysis of dreams. If these dream figures could be unmasked, we should know which act of repression had caused the distortion of mental life.

There is one serious defect in this figurative account; in fact, we have omitted the principal agent, the source of psychic energy. Above all, Freudian psychology purports to be a dynamic psychology, and its language is a language of forces, stresses, strivings, energies. Mental life is, above all, an interplay of forces; the ideas in this house-drama are "charged" with energy and "struggle" for expression. The energy charges, in turn, are originally derived from instinct; and although the process of transformation is not too clear, psychic energy is described as ultimately rooted in the organic. Freud speaks of ego instincts (directed toward self-preservation) and object instincts (directed toward external objects) and social instincts; but these appear to be merely useful classifications of behavior. The fundamental forces behind all these impulses are two in number: the libido and the death instinct. Like the protagonists in the ancient mystery play, these contending forces seem to typify the Forces of Light and the Powers of Darkness. The libido (Eros) is a synthesizing, constructive, creative force moving outward toward ever-closer union, while the death instinct is an impulse toward destruction, dissolution (both of the self and of the outer world).

The Libido.—The libido has been characterized as the Freudian correlate of Bergson's *élan vital*, as the life force. In answer to his critics, who have accused him of reducing all our impulses to the sexual, Freud asserted that he intended no such narrow definition

of the libido as was implied in the criticism. In fact, the term sometimes seems to serve as a symbol for all our impulsive striving. In spite of his theoretical defenses and qualifications, however, the libido emerges in the case histories which Freud has published as a striving toward sexual goals, in the ordinary sense of those terms. The one thing which, more than any other, distinguishes the Freudian method of handling mental disorder is his preoccupation with sex, and his assertion that there is no neurosis where there is a normal sex life.

But if Freud conceives the sexual impulse to be the prime mover in human affairs, it must be admitted that it is widely removed from the sexual instinct with which the biologist is concerned. With regard to its physiological mechanisms Freud has nothing significant to say. It might just as well be a totally disembodied "mental force," for merely to say that it is rooted in the organic throws little light upon its objective nature. Nevertheless, Freud believes that we can infer its essential nature from the mental processes which it produces, and he presents a sketch of the life history of the libido.

Development of the Libido.—In the beginning it is "polymorphous perverse." That is to say, it is well-nigh amorphous, having no definite shape, or goal, or attachment. Its interest is not centered exclusively upon the genitals and reproductive apparatus, nor is it directed toward a member of the opposite sex. And when we say "in the beginning" we mean something very near the literal beginnings of the individual, for in the Freudian account of the journey of the libido it is clear that its first great defeat occurs when the individual undergoes the shock of being born. From the "easy life" provided by the warm, protected position within the mother, where the assaults of external stimuli are reduced to a minimum, where no effort to secure food is required, the individual is rudely thrust forth into an alien world—and the struggle for existence begins. In the postures adopted by some of the insane, in dreams and fantasies of adults, and in the symbolism of many paintings Freud finds evidence of the libido's yearning for this earlier paradise. Thus the reappearance in many different myths of the notion of a Golden Age, a Garden of Eden, of some time in the long ago when men lived nearer to the gods, might be given Freudian significance if it were interpreted as a cultural expression of a deeper-than-conscious knowledge possessed by every individual. It is the life of the individual libido writ large upon the canvas of a culture.

Freud presents us with no infant "trailing clouds of glory," but rather with a little beast whose interests center upon the sensual pleasures of suckling, defecating, urinating. These are, in fact, the first expressions of the libido, and it is only later that libidinal interests gradually center upon the genitals. In fact, the "oral-erotic" and "anal-erotic" types of the clinician represent those who have never succeeded in making the normal transition. Auto-erotism, since the normal goal of the libido is a person of the opposite sex, is likewise a transition stage, normal enough at an infantile level—as a stage in development—but viewed as a pathological "fixation" when it persists in the adult. It may take the form of thumbsucking, voluntary retention or incontinence of feces and urine, or masturbation. In the course of time, however, the libido flows outward to embrace members of the family circle, playmates, and finally the normal sex object. It is subject, however, to the accidents of time and circumstance, and the neurotic adult is typically one whose libido has failed to achieve full virility (or femininity). An excessively solicitous parent, for example, may make it difficult for the libido of the child to achieve its final freedom, or the chance homosexual play of boys about the swimming hole may contrive to divert sexual interests into a perverted channel, or an individual who lives under an unusually repressive social code may find insuperable barriers placed across the normal channel of development.

Perhaps the principal retarding factor is the *fixation* of the libido upon the parent of the opposite sex. This, according to Freud, is accomplished in the first place by instinct, the love of the boy centering upon the mother, of the girl upon the father. The strength and "naturalness" of these attachments is demonstrated, Freud believes, by the very ferocity with which society punishes those who transgress the incest taboo. If the impulse were not powerful, we should not need legislation and the great weight of social disapproval to hold it in leash.

It was in the dreams of his patients that Freud found the chief line of evidence in support of this doctrine of parental fixation. Here the "Oedipus complex"[1] becomes an interpretative touchstone, and through its use Freud believes that what is otherwise a meaningless jumble of chance associations and fantastic construc-

[1] So named from the legend of Laius and Jocasta told in the drama by Sophocles.

tions becomes ordered, full of meaning. (We shall have occasion to illustrate the process of interpretation when we consider the question of dreams.)

It is not to be supposed that the son and daughter fully realize the import of these attachments. The child of from one to five has neither the biological development nor the ideas to render such a notion plausible. The boy will express his fixation rather in seeking expressions of affection (caresses, cuddling, etc.), in wanting to sleep with his mother, in monopolizing her attention, and in jealous attitudes toward his father (or brothers and sisters). In the adult, likewise, there is no conscious recognition of this Oedipus drama. Freud insists, however, that it is played out to the very end—in the unconscious. The jealousy toward the father is now elaborated into an unconscious wish for his death, and the "affection for the mother recognizes the goal of possessing her for a wife."[1]

We might summarize the development of the libido as divided into three periods: (1) the early period, extending to the fifth year, (2) a latency period extending to puberty, and (3) the period of adult sexuality. The early period is regarded as most fundamental of all, for here the basic patterns of libido development are established and, together with an inherited constitution, these patterns determine subsequent character (or neurosis). During the latency period little of import occurs. Sexuality is driven underground, only to bide its time until the rapid series of biological changes at puberty give it new impetus, and it bursts forth to assume an adult form. From an originally amorphous and undifferentiated quest for pleasurable organic sensation it has become centered upon the genitals. It has passed through stages of self-love, love of the parent, love of those like one's self (homosexual love), and—with normal good fortune—finally fixates upon a person of the opposite sex.

The history of the libido depends to some extent upon the sex of the individual, and in general the development of the girl is looked upon as fraught with greater difficulties. In the latter case a "castration complex" may arise through the child's recognition of what she believes to be her genital inferiority, and the Freudian attributes some of her hostility to her mother to the fact that she blames her mother for this inadequacy. Moreover, the role of the

[1] Freud, S. *A general introduction to psychoanalysis*, p. 291. New York: Boni and Liveright, 1920.

mother in the home makes it easy for the girl child to develop an attachment to one of her sex. Add to this a stricter code of conduct, and the path of the libido becomes a more difficult one.

Freud at first thought that a similar "castration complex" in the male arose from actual parental threats (possibly made in the effort to check masturbation), but later came to the conclusion that similar fantasies exist without any basis in fact. He attributed these fantasies to a "racial memory," transmitted from generation to generation by way of the unconscious. Freud looks upon this

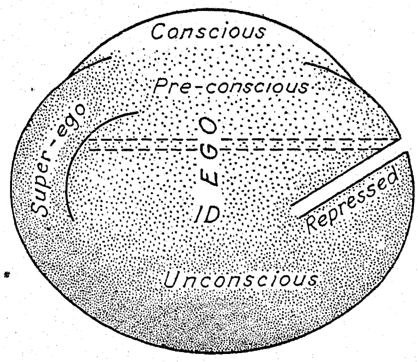

FIG. 99.—Diagram illustrating psychoanalytic conception of the structure of the psyche. The small unshaded portion at the top represents the conscious portion of the mind, and serves to indicate the analyst's evaluation of its relatively small role in determining mental events. *Ego* and *super-ego* are seen to have both conscious and unconscious portions, whereas the *id* is wholly unconscious. The cleft at the right serves to typify the barrier which walls off portions of the unconscious and makes necessary the tedious labors of the psychoanalyst. (*Modified from Freud.*)

complex as a natural expression of the jealous and hostile attitudes existing between father and son, and as one of the factors forcing the boy to give up all expression of his incestuous desire for his mother.

Freud also attributes to both boy and girl bisexual trends. Thus a nucleus of homosexuality is universal. Where external factors or inherited constitution is sufficiently strong, this homosexual trend may dominate the personality.

Mental Topography: Repression.—It is difficult for one accustomed to correlate psychological and physiological descriptions to make very much of the "mental topography" which Freud proposes. Whatever meaning the terms may develop within the analytic situation does not help us to refer them to any bodily structures or to any known physiological processes (Fig. 99).

Mental Levels.—There are, to begin with, three mental levels: the conscious, the preconscious, the unconscious. Immediately beneath the conscious level, and more or less accessible to it, lies the preconscious, containing ideas which have lapsed (or which have been repressed) from the conscious level. These are the memories which we can recall. There is always a certain amount of censorship at the border, however, and on occasion it may be so strict as to block recall completely. The material found on the preconscious level is of essentially the same sort as that which is in consciousness.

The deepest level, on the other hand, is inaccessible to all ordinary methods of exploration, and contains material wholly incompatible with that in the upper strata. It is no mere "lapsed consciousness" that is here intended; nor is it, as we shall see, merely the silent warehouse of the mind in which our forgotten past is kept in cold storage. Indeed, it is very much alive and contains the main sources of our psychic energy. Compared to the portion of the mind which is in the sunlight of consciousness, this deeper and unconscious level is like the vast submerged portion of an iceberg. Or, to change the figure, consciousness might be compared to the events of a few centuries for which we have a written history, the unconscious to all the events which have occurred since man has been on the planet. The Freudian book of Genesis opens with "In the beginning was the Unconscious . . . " It is as though the unconscious contains the primal stuff of the mind, and in the history both of the race and of the individual but a small fragment has been differentiated out to form consciousness. And that differentiated fragment is still somehow rooted in and subservient to the unconscious.

Again, between the preconscious and the unconscious there is a barrier, the censor. To do Freud justice, this personification is recognized for what it is—a mere figure of speech. Behind the figure is a process—call it resistance, inhibition, censorship, repression, what you will—which presents a functional barrier to the forces below the threshold and makes of every mind a thing divided. Some of the unconscious material may once have been conscious—and later repressed; much of it has never crossed the threshold. In addition to repressed infantile experience, the Freudian does not hesitate to posit a racial memory.[1] Thus, we might describe

[1] Where orthodox science is content to speak of a biological heritage and to think of the latter in physiological terms, the Freudian posits something very close to the long-ago rejected "innate ideas."

the unconscious as containing impulses and tendencies characteristic of the animal, the primitive, the infant. It is amoral, egocentric, illogical, infantile, sexual, and nonverbalized. It does not respect time relations, and is willing to harbor contradictory and antagonistic impulses.

Ego, Superego, and Id.—In Freud's later formulation, in addition to these levels there have appeared three entities: the ego, the superego, the id. Both ego and superego function at all three levels, but the id is wholly unconscious. The id (literally, the "it") is regarded as the source of the instinctive energy of the individual, the original home of the libido. While in no sense synonymous with the unconscious, the id partakes of all its characteristics. It is guided by the "pleasure principle"; that is to say, it seeks pleasure and avoids pain. Within the id, life-and-death conflicts occur (libido and death instincts ceaselessly struggle), and it is illogical, amoral, as are all other unconscious processes. It contains all repressed ideas, racial "deposits" of ancestral experience, and is regarded as the locus of all habit formation.

The ego is the very antithesis of the id, although derived from it by a process of differentiation which occurs mainly in the first year—though continuing until puberty. Figuratively, the ego is a fragment of the id which has been differentiated through the action of an external environment upon the original impulsive forces. Though commonly described as conscious, the ego has its preconscious and unconscious levels. The ego is logical, moral, verbal, recognizes the categories of space and time, and maintains a censorship (even, as in the dream, during sleep). It is the ego that is directly concerned with the world of outer reality and is the possessor of percepts, concepts, and the rationalized body of knowledge. Weak in the beginning, the ego grows through the education inflicted by reality, and through identification with objects of its affection (particularly the parent). The dynamics of the ego processes arise from the forces which play upon it; on the one hand, there are the instinctive forces pressing upward from the id and on the other, there are those forces of external reality. In addition, there is the superego, a fragment or outcropping of the ego. The superego is a kind of concentrated moral sense, or conscience, and, to a greater degree than in the case of the ego, confined to the unconscious. As moral critic it contains (and maintains) our sense of guilt, and this latter is promptly repressed in so far as possible by the ego. The superego arises out of the conflict between the impulse to love and to indulge

one's self and the impulse to be approved. It arises because the very ones he most deeply loves also thwart the child. Thus, the ego provides a kind of battleground for the warring superego and id; if the latter carries impulsive energy provided from ancestral inheritance (animal nature), the former is reinforced by inherited ancestral taboos, morality, customs, as well as by the promptings from an immediate external (particularly parental) environment. Chief among the forces of the immediate environment is the parent of the same sex.

Conflict, Repression, Resistance.—The mind is thus pictured as a scene of endless conflict; it is not one, but three. The very forces that gave rise to the differentiation of its parts are continuously active in maintaining the separation and in policing the borders between them. Repression begins in childhood and grows out of the anxiety which arises when parents disapprove of the unrestrained search of pleasure; and it is further maintained by society with its morality and taboos. (Freud does not hesitate to condemn our conventional morality, asserting that it demands more sacrifices than it is worth.)

Censorship and repression are ego functions. Ideas which are incompatible with reality or with the superego are banished from consciousness. The ego, in striving to maintain its own inner peace, acts as censor for consciousness. But, although the banished idea or tendency may no longer appear in consciousness, it does not follow that it ceases to exist. The energy charge of our ideas is too powerful, and derived from deeper sources; though banished from sight, they strive ceaselessly for expression, by indirect means where all direct channels are denied them. Substitute gratifications, indirect expressions, fantasy, dreaming, compulsions, and other neurotic symptoms, all give evidence of the potency of these submerged elements.

In psychoanalytic treatment this same repressive force reappears as resistance. Not only does the patient find no introspective evidence of the Oedipus drama imputed to him, but he vigorously resists the mental probing of the analyst, necessitating special techniques and prolonged treatment. In fact, the public's general unwillingness to accept the Freudian view of things is interpreted as but a special illustration of this same force. Just as he found evidence in the very force of the incest taboo for the truth of his theory, so Freud turns to good account the criticisms directed against

him. If his theories are correct, he argues, this is to be expected; only general indifference could disprove them.

There are many things which we like to forget. We forget appointments that are likely to be unpleasant. We forget to pay our bills. It is as though consciousness operated on the "pleasure principle," rejecting unpleasant ideas and discarding all sources of conflict. Some Freudians assert that all forgetting is intentional and that investigation will show that what superficially appears to be a mere "lapse" is either directly or indirectly associated with libidinous impulses which the ego has rejected.

Freud first came to his concept of repression in his search for traumatic memories. Impressed by the work of Breuer, Charcot, and Janet, each of whom found these traumatic memories of importance in explaining hysteria, Freud strove to direct his patients' introspection in this direction. In spite of explicit warnings against any deliberative selection of material, against rejection of material as indiscreet, irrelevant, nonsensical, etc., he found that his patients seemed to be exerting great ingenuity in outwitting him. They asserted that they could not think of anything, that what came to mind concerned someone else (and that, therefore, they were bound to keep silence), that it was trivial, or—after long pauses—that it was something altogether shameful. His patients raised all the objections that Freud was meeting in the scientific literature. And even when their resistance had been overcome, and an interpretation began to take shape, they insisted that it was all very interesting but irrelevant, untrue, and of no help in solving their illness. So active and persistent a force could scarcely be accidental. Freud therefore felt compelled to posit his censor, standing at the gateway of consciousness.

Freud's particular contribution to psychopathology lies in his insistence that the neurotic's symptom is a device, comparable to the symbolism of the dream, whereby this censor may be outwitted. More literally, it provides "a sexual satisfaction for the patient . . . a substitution for such satisfactions as they miss in reality."[1]

Indirect Expression of Repressed Impulses: Dreams.—What many consider to be Freud's most brilliant stroke appeared with the publication of *Die Traumdeutung* (1900). Psychologists had devoted little attention to dreaming (or sleeping). Dream phenomena were regarded as rather trivial and inconsequential con-

[1] Freud, *op. cit.*, p. 259.

structions woven out of the material of the preceding day. They were viewed as initiated by momentary stimuli, both organic and external, and as having little significance in the general life economy. The fantastic and improbable character of the dream was attributed to the general relaxation, the absence of a present (and pressing) external reality. Just as in a playful mood we permit ourselves all sorts of nonsensical associations and are prepared to view familiar situations from bizarre angles, so the dreamer's thought hops from one item to another, bound by the flimsiest of association bonds, unusual analogies, etc. The absence of the restraining logic of the workaday world was thought of as due to the absence of its stresses, motivations, preoccupations, and external supports.

In Freud's hands this relaxation of vigilance was promptly turned to account. The process of censorship, or repression, whereby the mind is split and a functional barrier established between the upper and lower levels, prevents us from ever directly studying the basic forces of the mind (unconscious, libido, id). The force which represses the forbidden thought will reappear as resistance to the probing investigator. If sleeping and dreaming represent a relaxation of the ego's censorship, we shall find that dream material provides the most revealing insight into the nature of unconscious mental processes. In short, for Freud a dream represents a *wish fulfillment*, a release of repressed libido which occurs when the censor momentarily nods.

Yet even the dream presents great difficulties and demands both extensive and intensive interpretation. In an example presented by Freud, the patient reports a dream in which he sees his uncle smoking a cigarette (on a Saturday). At the same time a woman caresses him as though he were her child.

Now the average reader will fail to see in this dream fragment anything of great moment; but Freud, in a half dozen sentences, reveals the hidden Oedipus complex. He notes, first of all, the presence of something tabooed; for the patient at once comments that his uncle (a pious Jew) would never smoke on the Sabbath. The woman, as the patient's free associations at once reveal, is his mother. It is obvious, Freud suggests, that these two ideas need to be linked, and by interpolating an "if" he translates the dream language as saying, in effect, "If my uncle could do such a forbidden thing (as smoking on Saturday) then I could enjoy my mother's caresses."[1]

[1] *Ibid.*, p. 155.

Dream Analysis: Manifest and Latent Content.—We may take this procedure as typical. Every dream, according to Freud, has both a *manifest* and a *latent* content. The manifest content, consisting of the story related by the dreamer, is a surface phenomenon, and it is to the underlying latent content that the analyst must always seek to penetrate. Here beneath the surface symbols is the real mental drama. The analysis of the sample dream presented above is not quite representative in one respect, for it is too speedy, too deft. Frequently the process of interpreting the dream story is a laborious one, running into hours. One analysis published by a pupil of Freud, O. Rank, contains a dream covering two pages of print, and an analysis covering seventy-six pages. Each object, relation, and action of the dream must be reacted to by the method of free association, and every mental bypath followed out. It is not enough that the analyst be familiar with common symbols utilized in dream formation; the dreamer must be made to confess the meaning of the fragment with his own lips. Only when his own processes of association have led him to the buried material will he be fully convinced of the correctness of the Freudian interpretation.

Although Freud is thoroughly contemptuous of the "dreambook" type of analysis, which assigns fixed meanings to the dream symbols, he comes dangerously near such procedure. Although he asserts that there are no "constant substitutes" by which we can decipher dreams, he does regard certain symbols as typical. The following list will suggest some of the most common symbolic relations:

Meaning	*Dream Symbol*
The dreamer's body	A house
Parents	King-queen (or other respected persons)
Brothers, sisters	Little animals, vermin
Birth	Water, swimming, diving, rescuing someone, being rescued
Nakedness	Clothes, uniforms
Death	Journey, riding on train
Male genitals	Sticks, umbrellas, poles, trees, weapons, faucets, fountains, balloons, airplanes, fish, snake, hat, cloak
Female genitals	Space-enclosing objects, pits, caves, pitchers, bottles, trunks, cases, pockets, churches, chapels, snail, clam, wardrobe, stove, room, jewels
Onanism	Sliding, piano playing

Although this list is incomplete, it serves to indicate representative symbols, and it also serves to indicate the type of interest which dominates the Freudian analysis. While familiarity with the common symbols might enable an analyst to make an interpretation

without any questioning of the patient, Freud regards such an ability merely as a supplement to the associative technique which alone can fully reveal the "psychic situation."

It should be noted that the dreamer does *not* recognize the symbolic value of the dream image, typically. Indeed, the very value of the symbol seems to lie in this fact. Neither need he have ever consciously noted any resemblance or relationship between the symbol and the thing signified. At times Freud appeals to a kind of "knowledge" which transcends the experience of the individual, as though these symbolic relationships were the production of racial memories possessed by the unconscious. That the symbolic value of many items in the list is generally recognized Freud thinks is proved by an examination of mythology, folk tales, Old Testament literature, and common figures of speech. Thus we might offer the vulgar idiom "bats in the belfry" as well as the philosopher's "windows of the soul" as symbols for the body. If there were no such thing as a racial unconscious, our very language might serve to preserve a conventional set of symbols for each new generation of dreamers. Again, when we speak of "running after" a woman, the aptness of the figure lies not in its accurate representation of an actual pursuit, but rather in its conveyance of a dimly felt psychological resemblance. The two types of pursuit have an affective (emotional) resemblance, not a literal or logical one. So, too, when the Indians speak of the President as the "Great White Father," or the devout Catholic speaks of his priest as his spiritual father, the metaphorical language indicates some common emotional experience, some common attitude. The Freudian insight into the mechanism of symbolism might thus be stated: neither past experience (contiguity, conditioning) nor logical relations govern the course of reverie. The symbolic relationship found in dreams depends upon a dimly felt (and possibly unconscious) emotional congruence.

But neither language nor racial experience (however conserved) is devoted exclusively to reproductive interests. Why should the symbolism of the dream invariably reveal some phase of the Oedipus drama? Granted that the taboos of civilized life offer more frequent opportunity for the repression of this impulse than most any other, is there any reason to believe that it is the only important impulse which is repressed? Or that such repression is the sole cause of neuroses?

Alternate Interpretations.—To these questions academic psychology—whenever it has considered the concept of repression—has replied, almost unanimously, with a negative answer. That dreams are frequently symbolic is undoubtedly true, but one does not need to posit a repressive censor to account for the symbolism; and most psychologists would not want to limit the meanings of such dream symbols, in advance, to any one field. The same looseness of construction and fanciful character—which we noted in dreams—is also seen in the maudlin productions of the intoxicated person, and in the speech of one who is fatigued. In these cases perceptions are dulled, associations occur on the basis of trivial and nonsensical resemblances,[1] and there is a general absence of directing, controlling "sets." Waking thought is also symbolic, but in consecutive and discriminative thinking the symbols are more rigidly selected. The thought marches more directly toward a conclusion. The absence of controlling sets and the freedom from any pressing problem situation in the external environment permit the dreamer a much wider choice among the available associations. The absence of controlling sets is further shown in the sharp breaks in the sequence of the dream, an item which further discounts the Freudian interpretation. If the unconscious provided an unlimited head of energy, held in leash only by repressive ego forces, and if, in sleep, the barriers of censorship are lowered, then the dream—of all mental constructions—should be the most purposive, the most clearly goal directed. Its meandering, disjointed, and generally inconsequential character belies the Freudian interpretation.

The Freudian emphasis upon the absence of the critical faculty in the dream is perfectly apt. During our dreams we often imagine that we have a solution to some problem that has been pressing us or that we have made a profound discovery, only to waken and find that what seemed to be gold has turned out to be a worthless brass check. Like the "wunnerful" idea of the intoxicated person, the dream discovery is likely to be a bit maudlin.

Even the broader designation of the dream as "wish fulfilling" is not altogether satisfactory unless the term "wish" is so broadened as to lose all its ordinary significance. When a father reports a dream in which he witnessed the death of his son in a football match, do we need to invoke the Oedipus triangle and insist that the father

[1] For example, a "klang association" in which the words evoked resemble one another on the basis of sound rather than sense (book—hook, bat—mat).

is jealous of the affection bestowed upon the son by his wife? When we learn that the dream occurred on the evening before a "home-coming game" when the father was visiting his son's college, and when we are told that the preceding evening had been devoted to a rally and conversation about the coming game, and when the father confesses that he has long worried about his son—the possibilities of accidents, etc.—it would seem that a more sensible explanation is in order. The perseveration of events of the day before, the thoughts which were milling about just before the dreamer fell asleep, and persisting reactions are sufficient to explain the train of images of the dream. From what we have learned about the muscular tensions which are present in all thinking (particularly in anxiety), it would seem that actual muscular tensions, persisting into sleep, provide the intraorganic stimuli which initiate the process. Similarly, the person who has worked late over his studies, to the point where fatigue forces him to stop, carries to bed with him an unrelaxed musculature which will provoke dreaming.

But while the Freudian will admit that physiological factors may initiate the dream and that events of the preceding day may provide its content, he insists that the use made of this material reveals the forces in the unconscious. The daughter's dream of her mother's death may seem to be amply contradicted by the devotion she has shown in nursing the mother through a long illness; but on occasion the Freudian will insist that it reveals the revolt of the unconscious against the burden placed upon the individual by the superego (and by the social code which demands filial devotion). This will seem especially pertinent if the daughter's devotion prevents her from getting married, etc. While interpretation of this sort seems frequently justified, it passes the bounds of credence when universalized. When dreams of falling have to be interpreted as a desire to fall morally, when a dream of a railway accident shows a tendency toward self-punishment for masturbation, one cannot but feel that psychoanalysis itself is the outstanding neurosis of our times. Is not the obsessive interest in sex itself pathological?

It is very difficult to submit this difference of opinion to experimental test. When Wittels[1] asserts that all those who approach the study of dreams by way of Freud's methods are "absolutely convinced" that the Freudian theory is sound, he is proffering something less than overwhelming evidence in its favor. Certainly all whose

[1] Wittels, F. *Sigmund Freud; his personality, his teaching, and his school*, p. 61. London: G. Allen, 1924.

dreams are so studied do not agree, for Freud himself speaks of those patients whose "resistance" cannot be overcome and who terminate the analysis feeling that nothing is being accomplished. And some analysts who have practiced Freud's methods have given them up as worthless. Shall we, following Freud, excommunicate them as clumsy dullards? The truth is that the psychoanalytic gospel is more of a cult than a scientific view. Apparently only those who have themselves been analyzed and have accepted the views of the leader are competent to judge of such matters. Belief turns out to be a matter of submission to dogmatic assertions, and not the outcome of the sort of demonstrations to which we are accustomed in scientific matters.

And other considerations must be faced. Where Freud repeatedly finds convincing evidence of the Oedipus complex, Adler finds evidence of a "compensation for inferiority." For Adler, the dream is a rehearsal of a struggle to achieve superiority. Since there is no reason for assuming some selective agency which would regularly send patients suffering from organic inferiority to Adler and those whose libido is fixated at an infantile level to Freud, we are forced to assume that the analytic situation itself contains the explanation for the interpretation.

An Analysis of the Process of Dream Interpretation.—Consider the logic of the "free association" technique, itself. A dream experienced the night before is related the following afternoon in the analyst's office, and the patient is asked to react to a fragment. Because the fragment calls forth certain words it is assumed that the *causes* and the *meaning* of the dream are being revealed. The analyst seems too seldom to be aware of the fact that his presence is an important factor in the situation, and that his previous conversations with the patient may have produced a mental set favoring one type of material. Nor are we told what it is that signifies the crucial point in a series of reactions. As a matter of fact, any word will yield a series of associations of indefinite length, and if we have a predetermined goal (infantile sexuality) and permit the series to run long enough, we are bound to secure relevant material. As a matter of fact, with a little effort we can connect any word with our desired objective within two or three transitions, and without straining at too-obscure relationships.

Dream analysis may provide a convenient instrument for exploring the intimate experiences of a patient; it is far from a convincing demonstration that the free associations reveal the causes. When

disordered dreams are initiated by a stomach ulcer, we do not expect the free association method to reveal the organic factors which were responsible. There is no reason why a physiological psychology should make an exception, in the case of the dream, to its general rule that all mental events may be considered as responses to stimuli. Among the conditions which it might consider, in the case of dreams, are: the organic state of the dreamer (*e.g.*, alimentary-glandular-postural conditions, tensions which persist from the preceding day), external cues (stimuli from the bed, covers, clothing, sleeping partner, street noises, morning light, etc.). The processes initiated by these conditions are elaborated and developed in terms of the individual's experience. The voices of people passing in the corridor may become the buzz of conversation at a reception in the dream. Water sprinkled on the face of the sleeper may initiate a dream in which the dreamer is riding in the prow of a boat with the spray striking his face. The stimuli call out appropriate associations (conditioned reactions), manufacturing out of recent or vivid experiences a more or less congruent picture. And one item of the dream leads into another, as any train of waking thoughts—save that there is lacking either sharply controlling sets or external, supporting situations to give order and direction.

When, hours later, the dream fragment is presented for free associations, both the organic and the external setting have changed. The present purpose of undergoing an analysis, the questioning physician (toward whom all reactions are directed) must alter the course of the associations. And in addition there is all the patient's knowledge of Freudian theory and the probable meaning of the symbols (*i.e.*, sexual), plus whatever suggestion, "education," and direction the analyst provides.

Even if by some miracle of abstraction the associations were truly "free," what would they tell us of the causation of the original dream? Would free association to the mirage of the thirsty desert traveler or the dream of food of the starving yield descriptions of parched mucous membrane or contracting stomach muscles (in any but the physiologically trained)? When we examine an idea it does not automatically backtrack to its cause, like a frightened rabbit running to its burrow. If it did, psychology would be a simple matter, and objective experimentation unnecessary.

Any mental fragment (as, for instance, dream symbol) will have an indefinite number of associations. Change the circumstances under

which the fragment is presented and different "meanings" emerge. None of these may have any causal significance. Just how representative are the associations revealed during analysis? Will this not depend upon how representative the analytic situation itself is? Beyond a doubt some items will be juxtaposed in the analysis for the first time, and hence some of the analytic productions must be regarded as new constructions. Obviously, these new relations could not possibly have caused the dream sequence.

It would appear from this analysis (of the analytic situation) that the unconscious—as it figures in the Freudian scheme of things—is a will-o'-the-wisp. There is no way of reading it directly. And there is no reason to suppose that the unconscious is any less responsive to external, changing conditions than the conscious. Certainly the organic background which from time to time breaks into the conscious stream is as constantly changing as it is continuously effective.

This is not to deny that some dreams may be of sexual origin and significance, or that some dreams are clearly wish fulfilling, or that others dramatize the struggle toward full virility or mastery. It is rather an affirmation that the problem of dreaming is as complex as any problem in behavior, that multiple causation is the rule, that no simple (or single-track) interpretative technique is of any value whatever. As a device for inducing conversation about intimate matters, dream analysis may have its uses. It is scarcely a diagnostic instrument.

Critical Summary.—Before Freudianism can become a part of the body of scientific knowledge, each of its concepts will have to be translated into a more objective language, and the painstaking process of accumulating quantitatively impressive data must replace the somewhat anecdotal, arbitrary, and dogmatic methods of its founders. So long as libido, ego, id, preconscious, etc., can be given no precise and objective meaning, the statements concerning them are neither true nor false, but merely irrelevant. Freudianism thus represents a literary and mystical psychology—not a scientific one.

The Freudian psychology prides itself upon being *dynamic*, and it achieves this quality, verbally, by appealing to the forces of instinct, which provide a head of psychic energy. Wishes, impulses, desires, purposes, propel the psychic (and physiological) mechanisms. How these imponderables move the body levers we are never told with any clarity. While psychology as a whole is struggling to

cast off its animistic and teleological swaddling clothes, Freudianism revels in this "infantile" mode of expression. Since these wishes, instincts, and psychic forces are wholly incommensurable (and not even open to observation), the descriptions of the Freudians can never achieve more than plausibility. They can assert that the neurotic acts "as if" he wishes to be coddled by his mother, or that his illness is a "defense." They can find wishes which will render the dream content intelligible. But their findings are never more than plausible, and alternate accounts in which other wishes and purposes are used to rationalize the conduct will have equal validity. As dream interpreters they can claim little superiority to the ancient soothsayers.

The most common charge against Freud is that he has oversimplified the problem of motivation in insisting upon the primacy (and ubiquity) of sex. With remarkable ingenuity he has succeeded in giving a sexual meaning to activities as widely diversified as making mud pies, showing affection for a teacher, playing the piano, constipation, painting a picture, etc., etc. It is true that every one of our acts will have a sexual aspect; they are performed by male or female, the performers all have mothers and fathers, each has suffered the "birth trauma," each has been psychologically dependent at one time in his history. But the question as to whether the sexual aspect of our acts is always the psychologically significant one is quite another matter. Even when the neurotic patient shows marked abnormalities in the sexual sphere, it by no means follows that the sexual difficulty is primary. Can otherwise abnormal individuals be expected to work out satisfactory adjustments in this difficult sphere? And when some form of autoerotism is extremely common (if not universal) in some stage of our life histories, it can have very little significance in explaining the difference between the hysterical and the normal. Janet estimates that possibly three out of every four neuropaths possess "distressing memories with a sexual content."[1] This is not equivalent, he asserts, to a proof that these memories are the cause of their disorders or that a significantly lower proportion of supposedly normal people have such memories. In such matters we cannot go beyond the opinion of experienced physicians, and however much Freud's "pan-sexualism" might seem to pass the bounds of reason (and violate what little psychological

[1] Janet, Pierre. *Psychological healing*, Vol. I, p. 623. New York: Macmillan, 1925.

wisdom we have), if medical opinion universally credited Freud's views we could not fail to be impressed. When, however, those who are qualified to express opinions differ from Freud they are criticized as failing to employ his methods properly, as having made incomplete analyses of their patients, as suffering from sex repressions themselves. Janet[1] playfully compares these dissenting practitioners with the skeptic who says: "I have read the sacred books and I find in them numerous contradictions and incoherences." The reply of the believer, like that of the Freudian analyst, clearly shows that his faith is unshakably founded upon a higher type of knowledge: "That is because you lack faith. If you had read the books with the eyes of faith you would not have seen any contradictions." The Freudian frequently seems to be more of a priest of a new cult than a laborer in the scientific vineyard.

Finally, there is the "cure argument." Analysts who follow the Freudian plan do produce cures. In what proportion we do not know. Neither do we know, of those cured, what has produced recovery. There are many factors involved in the hundreds of hours which the physician devotes to his patient, too many to admit of any certain interpretation. Was it the actual analysis, was it the "power of suggestion," was it a slow process of reeducation and redirection—or what? The figures cited by Drs. Hyman and Kessel[2] are impressive, and unquestionably place Freudian analysis upon a plane far above the grotto at Lourdes, electric belts, blue glasses, or Christian Science. The ability of a therapeutic method to produce more than occasional cures is proof, at least, of a limited practical value; but it is an altogether insufficient guarantee of the correctness of the underlying psychological theory.

Rationalization and the Unconscious

Clinical Origins of the Concept.—Rationalization is a concept, if not invented, at least popularized and given new force and meaning, by the Freudians. Growing out of the disillusionment of the physician who has dealt, for years, with the reasoning of the hysterical and semiresponsible, it serves as a reminder of the fact that the portion of human behavior which can be correctly described as rational is, after all, distinctly limited. It serves to emphasize the

[1] *Ibid.*, p. 634.

[2] Five out of thirty-three cases were cured, eleven helped. Thus nearly half showed some gain (see p. 309).

extent to which man is a creature of impulse, swayed by irrational (or perhaps better, nonrational) emotional forces—forces so deeply buried in his nature, so long forgotten, so complex and far-reaching that the conscious realm within which his reasoning about his own conduct takes place seems like the froth on deep waters.

We like to think of "reason" as the pride and glory of man, as the lamp which lights dark places and whose rays run ahead of us on the path of action. But as we listen to human reasoning, whether of the successful ones or of those baffled ones who explain their conduct in clinics, we come to feel that the field of action must be much broader and deeper than that little circle of awareness in which our conscious thinking takes place, that the heart has reasons which the intellect knows nothing of. Like the inversion in psychological thinking produced by the James-Lange theory of emotions, the Freudian has given new meaning to our verbalizations of our conduct. "We are sad because we cry" seemed a violation of all common sense, an inversion of the true relations; but it served to call the attention of a generation of psychologists (lost in the forests of animism) to physiological clues which have since done much to explain the mystery of emotion. In a like manner Freud's inversion, which would have it that we act first (as a rule) and then reason about it afterward, has helped to illuminate much of human thinking.

In other days, when the mind was neatly divided into three compartments (*i.e.*, into feeling, intellect, and will), there were many who were ready to describe the willing phase as the end result. When reason and conscious deliberation had done their work, then and only then, did action typically occur. And even now we base practical distinctions upon this logic: we speak of acts which are not preceded by a deliberative phase as impulsive, and we distinguish between "murder in the first degree" and other grades of guilt where there was no cold-blooded plan. If we follow Freud's reasoning such distinctions will have less meaning, for even in the deliberative action emotional and impulsive factors are given a dominant role, even when their action is hidden from the thinker.

Rationalization Defined.—Typically, we act or apprehend directly, immediately. A Freudian would add, "from unconscious motives"; Kempf[1] would phrase it, "impelled by autonomic strivings," and Allport might phrase it, "in accordance with our pre-

[1] Kempf, E. J. *The autonomic functions and the personality.* Washington: Nervous and Mental Disease Publishing Co., 1918.

potent habit systems." Even where, as is frequently the case, we (the actors) are able to observe and report an intervening sequence of deliberative responses we must remember that these, too, are actions of a sort; and there is no obvious reason to posit a special type of control simply because the deliberative responses are implicit. If unconscious (and physiological) factors regulate the overt actions, they may be assumed to regulate those which constitute the "stream of consciousness."

And having acted, *if questioned*, we seek reasons. We may or may not discover the true reasons. A psychologist, examining our account of the probable causes of our action, will say that we have a great deal of *insight* when our reasons agree with his. In general, a person may be said to have insight when he is aware of his own dominant mechanisms and has given some thought to his own emotional and behavior history, so that in any given case he is able to give a fairly adequate account of the development of the action in question. Or, he may be said to have insight when he is able to describe accurately the goal toward which he is striving, when he is able to give the meaning of the action in terms of its significance to his general life plan.[1]

In addition to his general knowledge of his own dominant mechanisms and of his emotional and behavior history, his insight—on any given occasion—will depend to some extent upon how acceptable or admissible, socially, the true motive is. One might say that his insight depends in a measure upon the questioner: the frankness which our most intimate friends inspire permits the exploration and discussion of a wide variety of possible interpretations, whereas the restraint (inhibition) produced by others prevents some interpretations from even entering consciousness.

This is but a way of emphasizing the fact that the rationalizing of our conduct is a response invoked by a questioner, occurring in front of a social censor. It is a response which is as much a function of this person as of the question he asks. When Carney Landis set up a camera to record the facial responses of subjects reacting to emotion-inciting stimuli he found that the same fixed expression appeared in

[1] When insight is used in this second sense it is clear that differences of opinion must be anticipated. Our general philosophical viewpoint, our conception of the goal of life in general, the set of assumptions upon which our psychology rests, are matters concerning whose validity there have always been sharp differences—differences not easily resolved by any experimental technique.

situations evoking widely varying visceral reactions; and one is struck by the parallel between the action of the facial musculature and these verbalizing, rationalizing reactions. If the laboratory situation, the presence of an experimenter, and the act of being photographed can prevent the facial expression from adequately reflecting the subsurface visceral changes, may it not be equally true that the inhibitions of the rationalizer (Freud's repression) spring directly from the real (or imagined) presence of the questioner?

The question, "Why did you do that?" calls for a personal-social form of reasoning, for a justification, for an interpretation of one's conduct that will arouse approval in the hearer. And in our own case we are prone to assign rather worthy motives; our whole "set" when our thought turns to our own status, our guiding "fiction" of ourself, tends to preclude any consideration of certain types of motives (*i.e.*, certain roles, functions, goals, drives). In rationalizing our conduct we are giving something less than an objective description of our conduct: we are the attorney for the defense, not an impartial judge.

From our own analysis it would appear that the Freudians have covered but one special instance of rationalization. Few of us can contribute critical essays to the current magazines on "The Pulse of Modern Life," and yet we are all *in* and *of* this stream of modern activity, our own acts are a part of the tide. To say that we are unconscious of the forces which sweep us into action may mean that we are unaware of them or it may mean that we are incapable of making an analysis of them; we need not invoke ego, libido, and id, to describe this fact.

And although the Freudian's assurance to his patient that he is of course totally unaware of the Oedipus complex may make the patient more ready to accept these "monsters of the unconscious" as a part of his make-up, we need not assume that this same type of "unconsciousness" is the root of all rationalizing. In describing the conflict of forces which gave rise to the constitution of the United States, V. L. Parrington writes:

In the privacy of the convention the speakers were free to express their views frankly, and in consequence a loose rein was given to the play of ideas; fundamental principles were examined critically and economic motives and class interests openly acknowledged. But in arguing the case before the generality of voters without doors a more cautious approach

was necessary; arguments must be tempered to well-known prejudices, and circumspection must take the place of frankness.[1]

What I should like to urge is that there is no sharp borderline between that circumspect speech which fully recognizes (but glosses over) real causes and those rationalizations where there is complete loss of insight (and the true motives are "unconscious"). The two extreme types are regulated by the same controlling circumstances.

Training the Child to Rationalize.—If we consider some of the child's descriptions of his own conduct we may catch a glimpse of the way in which this loss of insight comes about. Asked to perform some disagreeable task, he may simply respond with, "I don't want to," or "I am afraid," or "I don't like him," etc.; and if we reject his too-frank answers the young "reasoner" will come to see that only certain reasons are "real" reasons (*i.e.*, acceptable), and that other reasons are futile, blundering, blind-alley responses. He will probably have to perform the task anyway and, in addition, will have to make added efforts to win back parental approval and respect. In time, while he still continues to "think" of the same reasons, he will learn to inhibit their expression altogether. Although he still retains "insight" he may find it wiser to reply, "But don't you think I should be doing my home work?" or "But the doctor said . . . ," etc. And, if his social surroundings continue to make insistence upon a narrowly circumscribed set of reasons, he may soon come to the point where the "blind alleys" are completely eliminated, the "real" reason rises at once—and he is the complete rationalizer. If you suggest to him the old (now inhibited) reason, he will say, "Why, I never thought of such a thing"—which is perfectly correct—and he will probably be angered at your imputations.

In the situation we have described the "loss of insight" is compensated for by the improved (?) social adjustment which enables him, by an appropriate selection of speech reactions, to continue doing as he chooses, at the same time preserving friendly relations with and (possibly) the respect of his associates. A certain amount of rationalization is thus the inevitable product of socialization. It is possible that we might see our actions with a much clearer eye if parents and educators did not insist upon our giving such limited descriptions of our conduct; but it is a "utopian" hope to expect to

[1] From Parrington, V. L. *Main currents of American thought*, Vol. 1, p. 281. New York: Harcourt, 1927. Reprinted by permission of the publishers.

eliminate it. Perhaps the most profound insight is to recognize the lack of objectivity, the proneness to rationalization (*i.e.,* lack of insight), in all of our self-evaluation.

Evaluation of Rationalization.—From one standpoint, rationalization seems to be a type of mental inertia. As Robinson suggests, it is a process in which we find reasons for going on believing and acting as we have in the past.[1] Like the proverbial rat in a maze, we stumble upon a path, blunder into beliefs, and then proceed to justify them, finding that easier than to change. In truth, the forces that have guided us in our blundering guide us in our reasoning also. The emotional reenforcement which has figured in the selection of a course of action will also produce wishful thinking.

Hence one is led to describe a man's "philosophy of life" as a rationalization. We find ourselves living in a certain society, feeling a certain way about the universe; we are part and product of a most complicated history and environment. Before we reach the age of reason, this vast matrix of biological, cultural, and material factors has conspired to mold us into a certain pattern; and upon this as a basis our reason proceeds, seeking additional security and support as we labor to convince others that the world is just as we experience it. How else can one account for the difference between the pessimism of a Schopenhauer and the optimism of a John Dewey, or between the lusty appetite for living in the machine age shown by some of our contemporary thinkers and the *fin de siècle* attitude of others?

When one approaches the problem of rationalization from the viewpoint of the clinic, it is seen to be a part of that "flight from reality" symptomatic of so many types of abnormality. So viewed, the loss of frankness and candor, common enough in the rationalizations of normal people, may be viewed as the first steps on the way to the world of fantasy, of make-believe, of wishful thinking, that in the extreme becomes a pathological lack of orientation. No one can deny that, like daydreams, rationalizations can be comforting. They often save us from the expenditure of effort; they conceal the unpleasant; and it is entirely possible that they are a necessary protective device. One psychologist argues:

> It keeps the person within the limits of socially accepted motives. It offers a socially determined defense mechanism for conduct. It protects the person, in short, from the severe strain of reasoning and the solution of

[1] Robinson, J. H. *Mind in the making,* pp. 40–48. New York: Harper, 1921.

problems in a more objective but less pleasant way. So long as man is moved by emotions and feelings, so long as the "logic of feeling" controls us, rationalization will serve a very valuable purpose in maintaining some balance in the personality, even though the integration be not of the most satisfactory sort.[1]

In so arguing in its favor the psychologist seems to be unwittingly demonstrating the universality of the process, for is he not attempting to rationalize rationalization?

Creative Imagination and the Unconscious

Perseveration.—The effects of stimulation endure for some time after the withdrawal of the exciting stimulus. In general, it is the reaction which stirs us most deeply that thus perseverates: an accident, an arrow escape, an insult, some humiliating event, an amorous adventure. The studies of Lewin and his pupils (see p. 353) show that the perseveration effect is also strong in incomplete (interrupted) activities. Tasks which are cut short have a tendency to reinstate themselves, and they will be recalled with greater accuracy than those which are completed.

Indirect evidence[2] of this perseveration process appears in a comparison of the efficiency of various distributions of practice, as measured by subsequent recall. A practice period that is immediately followed by eight hours of sleep may be compared with a similar practice period followed by an equal interval of waking activities. If recall is tested at the close of the eight-hour periods, the former method is found to be superior. It would seem that the activities immediately following practice somehow disrupt a "setting process," and that, on the other hand, the period of sleep permits a perseveration and consolidation of the practice effects. A similar conclusion is suggested by other studies concerned with the distribution of practice. For example, one repetition of a list of nonsense syllables every second or third day yields more retention than an equal amount of time concentrated into fewer practice periods.[3]

[1] From Young, K. *Source book for social psychology*, p. 271. New York: Crofts, 1927. Reprinted by permission of the publisher.

[2] Van Ormer, E. B. Retention after intervals of sleep and of waking. *Arch. Psychol.*, 1932, 21, No. 137, 49.

[3] Perkins, N. L. The value of distributed repetitions. *Brit. J. Psychol.*, 1914, 7, 253–261. No general significance can be given to these particular intervals. Other materials might require a different distribution of effort. The

This fact may be explained by appealing, again, to the setting process which follows a given practice period. Where practice periods are crowded together, the setting processes overlap and the learner does not get the full advantage of this perseveration. Where they are separated, each practice period is followed by a perseverative process which strengthens the memory "traces" (thus working for the learner while he rests or is occupied elsewhere).

Perseverating processes may be fully conscious (reconstructing our after-dinner speech) or they may function without awareness (perseverating reactions to nonsense syllables during a night's sleep). Of these, the more creative type of activity seems to be the conscious one, but there is no obvious reason why the processes which continue below the threshold of awareness should not also show the same variability and inventiveness. Bartlett's demonstrations of transformation and conventionalization in recalled material suggests that the setting process is not so mechanical as the setting of plaster. And in the studies of hypnosis, the subjects who carry out multiplications, write poems, essays, and answers to questions (the entire processes occurring without awareness) show that these subliminal processes are in no wise limited to the mechanically perseverating effects of stimulation. On the contrary, cues are received, elaborated, and imaginatively developed.

Poincaré's Observation.—Poincaré, the French physicist and mathematician, attributes some of his important discoveries to such unconsciously perseverating and maturing processes. At one time, when he had been engrossed in mathematical studies for weeks, he dropped his unfinished work to go on a geological excursion:

> The changes of travel made me forget my mathematical work. Having reached Coutances, we entered an omnibus to go some place or other. At the moment when I put my foot on the step the idea came to me, without anything in my former thoughts seeming to have paved the way for it, that the transformations I had used to define the Fuchsian functions were identical with those of non-Euclidean geometry. I did not verify the idea; I should not have had time, as, upon taking my seat in the omnibus, I went on with a conversation already commenced, but I felt

age of the subject, his interests, his study habits, the complexity of the materials (and the need of a "warming-up" period), the size of the "natural units," must all be considered. The optimum distribution for a given task and subject must be empirically determined.

a perfect certainty. On my return to Caen, for conscience' sake I verified the result at my leisure.

Then I turned my attention to the study of some arithmetical questions apparently without much success and without a suspicion of any connection with my preceding researches. Disgusted with my failure, I went to spend a few days at the seaside, and thought of something else. One morning, walking on the bluff, the idea came to me, with just the same characteristics of brevity, suddenness and immediate certainty, that the arithmetic transformations of indeterminate ternary quadratic forms were identical with those of non-Euclidean geometry.

Returned to Caen, I meditated on this result and deduced the consequences. The example of quadratic forms showed me that there were Fuchsian groups other than those corresponding to the hypergeometric series; I saw that I could apply to them the theory of theta-Fuchsian series and that consequently there existed Fuchsian functions other than those from the hypergeometric series, the ones I then knew. Naturally I set myself to form all these functions. I made a systematic attack upon them and carried all the outworks, one after another. There was one, however, that still held out, whose fall would involve that of the whole place. But all my efforts only served at first the better to show me the difficulty, which indeed was something. All this work was perfectly conscious.

Thereupon I left for Mont-Valerien, where I was to go through my military service; so I was very differently occupied. One day, going along the street, the solution of the difficulty which had stopped me suddenly appeared to me. I did not try to go deep into it immediately, and only after my service did I again take up the question. I had all the elements and had only to arrange them and put them together. So I wrote out my final memoir at a single stroke and without difficulty.[1]

Analyzing the creative process, Poincaré would distinguish four stages:

1. A period of voluntary, conscious effort, during which materials are assembled (reading with a purpose, experimental and abortive attempts at solution) and the subconscious perseverative processes are set in motion.

2. A period of unconscious "incubation" and elaboration. Although the person may not be aware of the continuing process, work is being done. The materials are being recombined and reordered. New aggregates or clusters form around the main process. Parts which are nonessential (and incompatible with the main process) are crowded to the background.

3. The flash of illumination. There is an uprush of the maturing process into consciousness, and if the structure of the thought is not wholly complete, the

[1] From Poincaré, J. H. *Science and method.* Pp. 387–388. New York: The Science Press, 1929. Reprinted by permission of the publishers.

main lines are now so clear that the person feels certain that he has the solution within his grasp.

4. A period of verification, of proof, of final shaping, pruning, testing. The consequences must be elaborated, the whole given a logical (or artistic) form.

The Case of Coleridge.—How close a parallel exists between the work of the mathematician and that of the poet is admirably shown by Lowes's[1] study of Coleridge. For years before Coleridge wrote *The Ancient Mariner* he had been "reading with a purpose." His project, mentioned in his notebook and in correspondence, was to be a sequence of "Hymns to the Sun, the Moon, and the Elements (earth, air, fire, and water)"; the whole was planned as an attack upon atheism, an affirmation of the "tremendities of nature," and was to conclude with "a bold avowal of Berkeley's system" with God and the moral order triumphant over the foolishly proud atheism of Godwin. But if the artist read with a "falcon's eye," pouncing upon every item that showed possibilities, the trail of his thinking and reading left in the notebook shows such a diversity of materials that any single purpose can scarcely account for all that was selected. He notes, for example, that

> A dunghill at a distance sometimes smells
> like musk, and a dead dog like elder flowers . . .

and between jottings of verse he places a recipe for Irish stew, and one for brewing wine. Most noteworthy of all, perhaps, is the fact that the avowed purpose was never accomplished at all. There had been too many voyages of discovery: three centuries of exploration and conquest had produced a literature that was fascinating to Coleridge, as both the poem and the notebook bear witness. Coleridge, who had never set foot on seagoing ship, saw tropical seas and rounded Cape Horn in the pages of the travelers; he read of Laplander, alligator, tropical fish; of hoarfrost, inland pools, and storms at sea; of snow blindness, phosphorescence, and of loneliness at sea. Through the accounts of Father Bourzes, Captain Cook, William Bartram, Sir Richard Hawkins, Captain Dampier, and dozens of others his mind became stocked with travelers' lore, as did many another Englishman's of those days. Gradually the pattern of the great voyage took shape, a wandering and a spectral persecution that should follow some crime. The notion of the killing of the albatross was hit upon in conversation with Wordsworth, who had chanced to

[1] Lowes, J. L. *The road to Xanadu.* Boston: Houghton, 1930.

read, shortly before, that such birds (sometimes with twelve-foot wingspread) were seen by mariners doubling Cape Horn. For years Coleridge had been making his collection of observations; but on his afternoon walk with Wordsworth they began to take on a new organization. Once the Ancient Mariner was launched, the poem rapidly took shape, and four months later was finished.

Like the literary sleuth, Lowes followed the path taken by Coleridge in his reading: from the notebook he went to the works of the voyagers, and from the footnotes in the latter to other sources which Coleridge had sought. Many a figure which was never jotted in the notebook reappeared in the poem, and when the job of literary detection was completed, Coleridge's stanzas stand riddled with borrowed phrases. Lowes, following Poincaré, inclines to the view that these borrowed phrases, like the hooked atoms of Epicurus, had been milling about in the unconscious during the long period of incubation, forming new constellations, acclimatizing themselves within this Coleridge environment, until that time when the crystallizing idea of the albatross precipitated the whole structure.

To what extent shall we attribute the new structure to a slowly maturing unconscious process? To what extent is the new arrangement produced at the moment of insight, in the very act of composition? Is the process of creation an intrinsically regulated affair, or are the "matings" and "crossings over" determined by repeated assaults from without? What causes the disintegration and reassemblage of these layers of constellations stored at such widely separated times? And what are the regulating conditions?

Merely to raise these questions is to show the depth of our ignorance of these higher thought processes, and the long program of research that is needed before adequate answers are forthcoming. To describe the creative process as unconscious is neither to locate it nor to describe it. If conscious events present difficult problems, how much more of a mystery must attach to a process of this degree of complexity—a process which remains hidden until the moment of its completion.

To "account" for a specific creative act, particularly one of the magnitude of Coleridge's *Ancient Mariner*, is scarcely within the range of experimental science. Even its "history" demands a breadth of knowledge and a depth of understanding which few possess, and the critical-historical process itself consists of such delicate *aperçus*, penetrating insights, that it seems far removed from

the foolproof knowledge of the technician. But those who will shed light upon the creative process for us will scarcely abandon it to the unconscious. They will explore (with historian, critic, biographer) the artist's relations to other persons: to a literary school, to his family, to his audience. They will seek to grasp that *Zeitgeist*, the philosophical and cultural climate of his times, and the social-political trends of which he was a part. They will seek to render explicit the literary forms and critical standards under whose sway his apprenticeship was served. And when all these "pressures" have been given explicit form perhaps the "creative unconscious" will seem less an intrinsically determined affair. Another way of summarizing our argument might be to say that, for psychologist or literary critic, the unconscious can never provide but a halfway house: the more we attribute to it the more insistent is the call for objective studies of the factors which regulate this process which is itself so completely out of sight.

Possible Interpretations.—One aspect of the problem deserves more explicit formulation. Let us consider a succession of experiences (activities) A, B, C, D, each one of which is composed of numerous items. A includes a, a', a''; B includes b, b', b'', etc. These reactions occur while the subject is struggling with a problem. The activities are conscious, voluntary, motivated; but, in spite of all effort, they do not release the tension, the problem remains unsolved. There follows a period of incubation in which the subject may rest or may engage in unrelated tasks. Either during this period or at the moment of returning to the task the solution emerges (*e.g.*, a combination—a, b', c'', d'''—which has not appeared before) and it is recognized as the key to the problem. Alternate possibilities suggest themselves:

1. Putting the task out of mind is in reality putting it into the mind. The incomplete process continues as an unconscious trial and error. This is the view of Poincaré and Lowes, and it is strongly suggested by the studies of pathological material reported by Janet, Prince, *et al.*, and by the experimental studies of hypnosis by Hull and others.

2. The alterations in the structure of thought are unconscious. However, instead of viewing them as a single continuous process (intrinsically determined), they may be thought of as discontinuous, sporadic, and externally initiated. Events X, Y, and Z (occurring in the incubation period) strike into the deeper levels of the mind and, through remote connections with A, B, C, D, reorganize these constellations.

3. The alterations occur in moments of fragmentary recall and may be wholly conscious. The task is not really "out of mind." The thought of the forthcoming lecture we are to give recurs again and again, interrupting other tasks, and each time the structure of our anticipated discourse is slightly developed and altered. When we finally reach the time allotted for the composition of the lecture we find that the main outlines are there, and that it writes itself. But the final performance might be looked upon as the culminating trial in a series of attempts, notwithstanding the fact that we had intended to postpone all work upon it until the final moment.

4. The new organization occurs at the moment of the successful solution. The final emergence of the new configuration may be brought about by a change either in the individual or in the problem situation.

a. The individual who returns to the task is, in a sense, a different individual. The just-preceding events, whose perseveration is always a determining fact in our reactions, are different from those present at earlier attempts. Elements which were active before have "faded" at different rates, and the task now revives a different constellation. Momentary physiological states have altered.

b. The problem situation may have altered. Items which were nonessential, but which nevertheless affected our responses (inhibiting the correct response), have dropped out.

5. Where the solution "pops into our head" during an interval when we are relaxed, diverted, there will necessarily be some stimulating condition. Every reaction has its stimulus. To say that the reaction is thrown up from the unconscious is but a figurative (and somewhat animistic) way of confessing that we are not conscious of the cause of the reaction.

A Concluding Note on "the Unconscious."—The studies which we have reviewed show conclusively that purposive, creative, intelligent acts may occur without our being aware of them. When we refer to these as *the unconscious* we need always to remember the activities; otherwise our concept will simply provide a fresh instance of animism. As a mind within a mind, the concept of the unconscious solves no psychological problems. Perhaps the greatest advance that has come with its recognition lies in the added importance which it gives to objective studies.

CHAPTER XI

REASONING

Reasoning and "Reality"

Like so many psychological terms taken over from everyday speech, *reasoning* does not point out a special process or faculty that is easily isolated or defined. We hear it said that man is the only rational animal; that animals solve their problems by blundering, or by instinct, or by sheer brute force, whereas man can solve his by the exercise of reason. We speak of a young man as having attained the age of reason. We reason with our adversaries, and—if reasonable—listen to reason. We find a stubborn adversary (like high prices) unreasonable, and we are likely to describe our opponent as moved by irrational impulses. What is the meaning of this verb, "to reason"?

We can scarcely equate the activity with thinking (symbolic activities) if we follow the canons of common usage, for fantasies, dreams, delusions of persecution, all fall within this more general category; and our sense of word values would make us hesitate to apply the term "reasoning" to all these. Somehow we like to think of the reasoner as "bound by reality" in a way that the dreamer and the schizophrenic are not. In our daydreams our wishes and fears work themselves out in unrestricted fashion; we permit ourselves victories, conquests; we marry the boss's daughter, sway the audience, go "over the top," giving free rein to fancies which in more alert moments "sober reality" completely represses.

There is a close parallel between the fantasies of normal people and the delusions of the insane who—we say—have "lost their reason." The absurd conclusion of the paranoiac who saw in the finding of a piece of thread in his soup a proof of his relationship to Miss Threadway[1] represents a type of transition in thought which could be duplicated in the dreams of normal people. The paranoiac, however, lacks that ability to "return to reality," to take an "objec-

[1] Bleuler, E. *Textbook of psychiatry*, p. 45. New York: Macmillan, 1924.

tive" attitude; he seems caught in the meshes of his own wish-fulfilling fantasies.

But if in our example the test of "reality" seems clear, it is not always so. We dispense with the criterion when we deal with the child and smile as he prattles of Santa Claus, the Easter Rabbit; these harmless delusions please him so, and "sober reality" will teach him soon enough. But how shall we treat the adults of an earlier day who believed that a "soul" flew out from the mouth of a dying man, that a "god" could change himself into a serpent or an eagle? Shall we treat these as a race of grownups who behaved as children simply because mankind as a whole still lacked experience? Shall we characterize a whole historic period as "prelogical"? These "events" which we now smile at were once very *real*, they passed the tests of experience of the "best minds." Viewed in their setting, these "events" were as real as the miracle of the virgin birth and as "true" as the doctrine of transubstantiation to our devout contemporaries. One cannot escape the inference that "truth" and "reality" are terms with both a valuistic and a social meaning. They serve not so much to mark off a peculiar type of mental process in the individual as to relate his views to the "world of fact" that is accepted by a larger social group.

One of the clearest examples of the group-determined character of "reality" lies in the contrast between the world views of the "class-conscious" worker and the "liberal" social scientist. Professional revolutionaries pride themselves upon their "objectivity," and truly where their very lives are at stake they have every need to know "things as they are." And yet we find a social psychologist referring to a sample of their pronouncements as follows:

> Here is a perfect example of the extreme attitudes of a *violent* in-group against an out-group. This is not unlike similar attitudes in *fanatical* religious organizations or among the ardent citizens of a nation in time of international war. *Revolt* from the authority of any other groups is evident, and the *fantastic romanticism* of a *utopian* future is also clearly apparent. This is the ideology behind the communist movement the world over.[1] [Italics mine.]

The impartial student[2] seems forced to conclude that there must be two "realities" here, the reality of the Third International and the

[1] Young, K. *Social psychology*, p. 337. New York: Crofts, 1930. Reprinted by permission of the publishers.

[2] The "impartial student" becomes an untenable fiction the moment he claims

reality of the liberal social scientist. Clearly, reality is the group-sanctioned view of the world, the "truth" men live by. Its value and permanence will be relative to those who live by it. It is historically conditioned, the product of no single individual mind or inventor, a growing and developing thing passed from each generation to its successors. "Reality" is not so much a criterion demarking a peculiar process (reasoning) in an individual "mind" as a description of a relation between the mental constructs (thoughts and behaviors) of the individual and that mass of traditions, actions, beliefs, interpretations of his group.[1] Alienation, in the psychiatric sense, is thus literally an alienation from the group.

Reasoning as a Type of Reorganization of Behavior

Do Animals Reason?—Let us turn for a moment to the field of comparative psychology. Perhaps here we can simplify our problem and escape some of the social and linguistic difficulties. What is the fundamental defect in animal behavior which has led so many to insist that animals do not reason? And what, on the other hand, is the nature of those acts which lead some investigators to insist that at least a rudimentary form of reasoning is present—even in the lowly white rat?

We have seen (page 376) how Thorndike and other students of animal learning came to a very disparaging view of animal intelligence. Thorndike's investigations exposed the excesses of Romanes, Wundt, and others, who so generously supplied "introspective reports" for their animal subjects. Whereas his predecessors has been ready to endow animals with elaborate rational and ideational processes, Thorndike concluded that animals do not draw inferences, that they lack ideas, that their solutions are achieved by a blind, trial-and-error sort of blundering. They failed to imitate the experimenter or another trained animal of their own species; and they did not learn new coordinations by being put through the acts.

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a special validity for his reality. He, too, is a part of a living culture and occupies but one of many possible vantage points. (And having chosen still another vantage point from which to view the impartial student we are well launched upon that "eternal regress" which haunts the philosophic quest for the ultimate, the absolute.)

[1] By the same sign, the evolution of reason is an inseparable part of the evolution of human society. The canons of "truth" and "fact" will shift as the social basis of the individual's thinking undergoes development.

Instead of sudden "insight," he found a slow "stamping in." Among other things he called special attention to the gradual slope of the time curve, finding in its gradual descent evidence that the learning process consisted in the gradual wearing down of brain paths rather than in the speedy decisions of a "rational consciousness."[1]

Watson's view was equally disparaging (but for different reasons). He wrote:

> From our point of view it can readily be understood that the search for reasoning, imagery, etc., in animals must forever remain futile, since such processes are *dependent upon language or upon a set of similarly functioning bodily habits put on after language habits.*[2] [My italics.]

Watson's argument, bluntly stated, runs: Reasoning is a special form of language habit. Animals do not possess language.[3] Hence it is futile to expect them to reason.

These views of Watson and Thorndike raise two questions:

1. Is the Thorndike description of animal behavior in the learning situation correct?
2. Is there any justification for the Watsonian premise that all thinking and reasoning are "special forms of the language habit"?

The Gestalt View.—The more recent evidence leaves no room for doubt on the first question. Although animals frequently behave according to the classic trial-and-error formula, there are too many illustrations of "sudden closure," of "insight," for us to accept the unqualified Thorndike formula. In fact, the Gestalt psychologist has used such cases as a basis for his challenge to the whole stimulus-response concept of behavior, and he would select these as typical—regarding the blundering as a special instance. Such sudden solutions as were shown by Köhler's ape, when banana and stick fell in line in its visual field, force us to consider the interrelations between stimuli. We can no longer neglect the perceptual factor in learning. In fact, the work of the Gestaltists has forced a general recognition of the fact that behavior is much less "piecemeal" than we had supposed, and much more a matter of "structuring a field," of an *organization* of movements.

[1] Thorndike, E. L. *Animal intelligence*, p. 74. New York: Macmillan, 1911.

[2] From Watson, J. B. *Behavior*, p. 334. New York: Holt, 1914. Reprinted by permission of the publishers.

[3] *Ibid.*, p. 321: "So far no language habits have ever been found in animals, nor has any one succeeded in developing such habits in them."

But in such instances as Köhler's ape typifies, the "2 and 2" which are "put together" are present in the field before the animal. If such sudden solutions represent reasoning, then insightful learning, perception, and reasoning fuse so completely that distinctions between these terms become psychologically meaningless. We should be forced to posit reasoning wherever there is reaction-to-relations.

Examples of Reorganization.—More recently, investigations of Maier, Shepard, and others show that the animal is able to organize activities which have occurred at widely separated intervals. In one

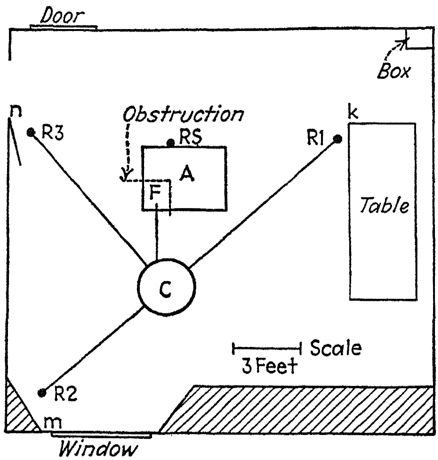


FIG. 100.—Arrangement of apparatus used in testing "reasoning" in rats When placed at A the animal is required to combine different past experiences in order to achieve an indirect route to the food F. (*Modified from N. R. F Maier. Reasoning in white rats. Comp. Psychol. Monogr.*, 1929, 6, *p.* 23. *By permission of the publishers.*)

of Maier's experiments, a table (A) (see Fig. 100) is placed near the center of a room. A ringstand (RS) provides a "ladder" by which the animals (rats, cats) are allowed to mount or descend from the table. The fenced-off portion (F) is inaccessible from the tabletop. After the animals have been given the freedom of the room for several days (during which time they frequently explored A), a second table (C) is introduced. It is joined to F by an elevated path, and with the ringstands $R1$, $R2$, $R3$. At this stage the animal is placed at the base of $R1$ (or $R2$, $R3$) and urged to ascend and traverse the path to F (via C). This is repeated until the $R1$-F maze is learned. In the test situation which follows, the hungry animal is placed at

A, with food at F. At this point "trial and error" appears; but after a period of running back and forth between the cage and edges of the table, struggling at the cage, etc., the animal descends RS, goes directly to the ringstand used in the training series (R_1) and travels directly to the food. Two habits, independently established on different occasions, are thus fused into a third integration.

Shepard reports an observation which indicates, even more clearly, an ability to "put 2 and 2 together." When a rat has learned the maze shown in Fig. 101, an opening is made in the alley wall at X.

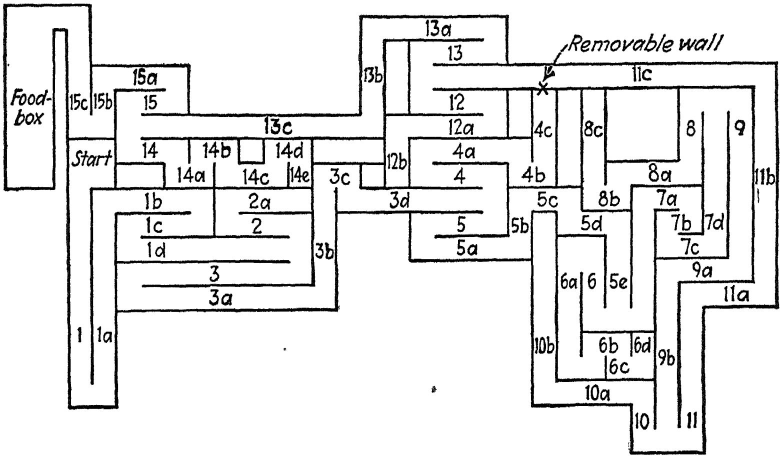


FIG. 101.—Maze used in Shepard's test of "reasoning" in rats. Odd numbers refer to true path; even numbers to blind alleys. After the rats have learned the maze the section X is removed, thereby making a short-cut through what had previously been a blind alley. (*Courtesy of J. F. Shepard. From N. R. F. Maier and T. C. Schneirla. Principles of Animal Psychology*, p. 468.)

Since the blind alley (4*a*, 4*b*, 4*c*) has been eliminated, the rat starting at 1 will not react to the opening X until he discovers it at 11*c*. In the experimenter's words:

He explores a few inches into the former dead-end, and then proceeds to the food box. He is removed and placed at the starting point again. Success is shown by his ability to turn at the appropriate junction, through the former blind alley and direct to the food box. This problem is made much more difficult if a section of new path, hitherto unexplored, intervenes between the end of the old blind and the true path section later in the maze. In a series of such tests, 100 and 101 showed nearly perfect results.[1]

[1] Shepard, J. F. Higher processes in the behavior of rats. *Proc. nat. Acad. Sci.*, 1933, 19, 149–152. Reprinted by permission.

Thus, although in both instances we may describe the behavior as "past-determined," the activity in the tests is neither a duplication of former acts nor a blind, fumbling trial and error. Rather, the test situation shows a fusion, a reorganization of disparate activities. It is not a case of remembering *A* or *B*; in fact, the test situation contains stimuli which should revive *both*. Instead, however, of being confined to one or the other of two responses, a *third* activity—a new combination—emerges. If we were to commit the unpardonable methodological sin, and put ourselves in the place of Shepard's rats, our introspective account might run: "I remembered the open door, which I thought opened into alley 4, and I thought I would see if I could make a short cut." Now, rats are not ordinarily credited with such complicated representative factors, and there is, of course, no evidence whatever of language. Rats cannot "talk to themselves," nor to experimenters who would like their verbal reports; but their behavior—especially in the instance reported by Shepard—shows the type of fluidity (and capacity to reorganize itself) which we are inclined to attribute in our own case to our "images," and to our capacity to make a verbal analysis.

In addition to the facts just noted, Shepard reports that there is no correlation between this "reasoning" and the ability to learn the maze in the first place. Maier[1] likewise distinguishes between two abilities, *R* (reasoning, reorganization) and *L* (learning), and finds that animals with cortical lesions (18 per cent or more) may make chance scores on *R* tests and still show ability *L* unimpaired.

Further support to the notion that disparate abilities are involved in "learning" and "reasoning" (as here defined) is given by other comparative data. Numerous investigators have shown that such insects as the ant and the bee are able to learn rather complicated mazes. Schneirla notes, however, that when a maze that has been learned as a path from nest-to-food is presented as a part of the return-to-the-nest-path it has virtually to be learned as a new problem. Stereotypy characterizes the species as a whole. Now, whether or not we attribute the emergence of the greater fluidity and flexibility which characterizes higher animals to the sheer increase in the "number of connections"[2] (and to the greater range

[1] See p. 464 of Maier and Schneirla's *Principles of animal psychology* (New York: McGraw-Hill, 1935) for a summary of the point.

[2] Cf Thorndike, E. L. *Human learning*, pp. 147 *ff*. New York: Appleton-Century, 1931.

of competing "controls"), it is clear that there is a great gulf between the stereotyped routines of insects and, let us say, the behavior of Köhler's ape, Tschego. When, for example, Tschego had been trying for some time, with no success, to reach the bananas outside her cage[1] she

> jumped up, went quickly into her sleeping-den, which opens into the cage, and returned at once with her blanket. She pushed the blanket between the bars, flapped at the fruit with it, and thus beat them toward her. When one of the bananas rolled on to the tip of the blanket, her procedure was instantly altered, and the blanket with the banana was drawn very gently towards the bars.[2]

Here is a new organization of behavior taking place suddenly before the observer's eyes. The stresses created by the problem situation seem to be able to break up the system of "traces" (memories) of earlier activities and to reorganize them so as to release the stresses of the moment. There is no old blanket-beating-banana constellation to call upon. There has been blanket-to-lie-upon, blanket-to-tussle-with, and numerous other traces; but "under the stress of the felt want" these traces are transformed. It would appear that the "concept" of a "something-to-reach-the-banana-with" arises out of the futile reaching, straining; and Tschego's dash to her sleeping den raises a serious question for the Watsonian view of things. Tschego may have been handicapped in communicating her wants to others, but she was by no means limited to the routine solutions of reflex and habit; nor were her adjustments confined to an immediately present group of stimuli. Instead, as in Tinklepaugh's experiment (see page 351), they point beyond the visible field, orienting her toward the hidden blanket, and thus portray one of the aspects of the "image" or "thought."[3]

[1] In this instance the sticks were at the opposite wall and hence out of her range of vision.

[2] From Köhler, W. *Mentality of apes*, p. 35. New York: Harcourt, 1926. Reprinted by permission of the publishers.

[3] After all, the ape's behavior is as legitimate a basis for inferring "expectancies" and "thoughts" as any of the actions (including the verbal) of our fellow man. Whether we should assign to the ape a consciousness that is at all comparable to our own may seem a nonscientific question; but it does seem necessary to think of the sought-after-object as in some sense present in advance within the ape.

The Stability of Traces

Motivational Stresses.—The insightful performance which we have presented as illustrating both the essence and the dawn of reasoning also illustrates a fact which Bartlett repeatedly emphasizes in his study of remembering; namely, that the memory trace is subject to alterations, transpositions, etc. And in the reasoning situation we see the alterations taking place in the direction of the solution. Structures are broken up, separately formed impressions are fused, and fragments acquired at different places, different times, are jointed together; and under the pressures of the problem situation the remembered object takes on new characteristics as it is fitted into the gap in our behavior, releasing tensions. The relation-to-the-present has transformed the trace.

Köhler comments on a similar fact in his own experience. As he watched his ape subject before the solution dawned, it seemed to the experimenter that every object in the field (every straw, stick, and stone) pointed toward the objective. And psychologically, the stick-to-reach-the-banana-with is a vastly different object from a mere stick-lying-on-the-ground. The insight "warps" the object, endows it with new properties.

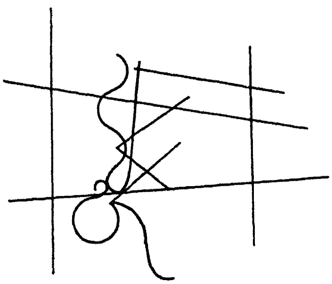


Fig. 102.—Figure in which part is easily isolated. Notice how easily the 4 is seen. (*From W. Köhler. Gestalt psychology, p. 210. New York: Liveright, 1929. By permission of the publishers.*)

Context and Configuration.—In this connection it is interesting to note one of the problems which proved difficult for the ape. When the stick had to be "manufactured" by breaking a small branch from a tree, the difficulty was enormously increased. Descriptively the branch was "bound" within the "tree configuration." Similarly, a box upon which someone was sitting did not seem as "free" as an unoccupied one, when the problem called for its use in climbing for an objective. Small boards nailed to a box were not pried loose (unless one was visually separate from the rest). In all this the Gestalt psychologist is prone to emphasize the optical-spatial properties of the field, and it is possible to gather numerous examples of similar dynamic factors from the field of visual perception. Thus, in Fig. 102 the 4 is not easily isolated from the context; in Fig.

103 the *K* is likewise "bound" within its matrix; and in Fig. 83 (p. 481) the *a* figure is not easily seen in the *b* figure. On the other hand, the parts of Fig. 104 are easily segregated. In the search for the principles which govern the operation of such aggregates the Gestalt psychologists have exercised much patience and ingenuity.[1] What should here concern us is the fact that the amount of experience we have had with a fragment of a field does not wholly account for its "free" or "bound" condition. There are relational factors (dynamic properties of the field) which govern the parts.

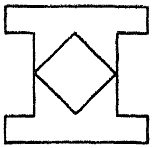


FIG. 103.—Figure in which part is embedded. (*From W. Kohler, op. cit., p.* 211. *By permission of the publishers.*)

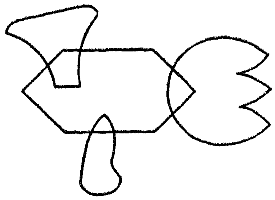


FIG. 104.—Figure in which the experience factor contributes little to the ease of isolation. (*From K. Koffka. Principles of Gestalt Psychology, p.* 158. *New York: Harcourt,* 1935. *By permission of the publishers.*)

Isolating Traces.—May we not employ a similar notion when we consider the process of disintegration and transformation of traces demanded by the reasoning facts? There are two points in the reasoning process where the "effect of the context" may balk solution:

1. The perception of the difficulty. The key-to-the-situation may be a familiar item for which we have an adequate response, but it may be so buried or bound within the physically present context that the solution does not appear.
2. The isolation of a "trace fragment" from its context (restructuring of experience) may be hindered by similar forces.

The first type of difficulty raises the problem of insight, which we have met in presenting the Gestalt psychologist's analysis of the learning process. Here the problem does not call so much for a new organization of movements as for a proper definition and diagnosis of the situation. Just as a physician knows what therapeutic steps

[1] Koffka, K., *Principles of Gestalt psychology*, (New York: Harcourt, 1935, provides an excellent summary and interpretation of these findings.

to take as soon as the obscure group of symptoms is properly classified as "tuberculosis" (his training has established these habits), so countless problem situations yield as soon as we spot the significant item or relationship. The analysis which we proposed in connection with the earlier discussion of the attention process is applicable here. Striking symptoms (not ordinarily associated with the disease in question), false preconceptions (sets, expectancies), may mislead the diagnostician. And in addition to the traditional "subjective" and "objective" factors we shall have to consider those relational (configurational) aspects which the Gestalt psychologists have emphasized.

This same problem of selection is repeated in the second difficulty. Just as an item or an "aspect" of the visual field may be difficult to isolate and may hence elude the perceiver (cf. the hidden face in the puzzle picture), so one may possess the requisite memories but find them unavailable at the moment. Nor will the mechanical factors which are often named as determining the strength of association bonds (frequency, recency, intensity) cover the case. In addition, there is the factor of set (which may inhibit the arousal of the relevant response) and a group of configurational-contextual forces.

The effect of this contextual factor in both types of difficulty is illustrated by Harrower's experiments.[1] Subjects were given incomplete jokes and asked to complete them. Where they failed they were given additional material which contained the solution. This material was of two kinds: connected prose and disconnected sentences. With the exception of one case, the connected prose failed to help, whereas sixteen cases found the loose sentences of assistance. This difference in the material held true whether the passage was read before or after the problem was presented. In one case it was a question of isolating a solution externally present, in the other it was a question of the availability of a trace fragment. In both cases the type of context and the degree to which the part was "embedded" within the whole proved an important factor.

It is clear, therefore, that *having* the information and being able to *apply* it are two quite different things. A stimulus-response psychology which considers the external situation as a mere aggregate of isolated elements would have difficulty in accounting for this fact.

[1] Harrower, M. R. Organization in higher mental processes. *Psychol. Forsch.*, 1932, 17, 56–120.

Transfer of Training: Training to Reason

The problem of reasoning may be rephrased. Reasoning is involved in the application of an old experience to a new situation that is partly like the old and partly new. Thus, we may ask, To what extent is training in situation *A*, a preparation for adjustment to situation *B*? This is the problem of transfer of training. It is a problem facing all educators.

A vast accumulation of experimental evidence shows that it is not a question that can be answered easily—even in general terms. For instance, should colleges continue to demand Latin as an entrance requirement? Does the study of Latin train the mind, or the faculty of reasoning? Obviously, no modern psychologist can subscribe to such justifications. Does it contain materials that are important for later studies? Does it establish a type of work habit and hence have a disciplinary value? Obviously, if its value is purely disciplinary and if the materials are not of some intrinsic value, the study could well be replaced by other materials (equally difficult and well organized for teaching purposes) and of greater usefulness.

Questions of this type have been endlessly debated in educational circles, and the tide is turning remorselessly against the "dead languages." In spite of the number of "common elements" between Latin and the modern languages, it has proved very difficult to demonstrate by educational measurements any great gain in English, French, or Spanish grammar and vocabulary as a result of earlier preparation in Latin. The slight superiority in first-year French shown by college freshmen who have had four years of Latin in preparatory school is not such that it warrants the excessive expenditure of time if French is the objective. Four months of college French would be more valuable than four years of Latin in the high school. The same would hold for English grammar and vocabulary. In other words, the "transfer effects," even to the superficially similar language material, are surprisingly small. The number of studies of similar import incline one to generalize: the subjects included in a curriculum should either be valued for themselves or else be very closely related to activities so valued, for neither remote transfer effects nor general mental discipline can be given experimental support.

This problem has received much attention in educational theory. Shall we say that transfer may be expected in proportion to the

number of identical elements? On the face of it, this would seem to be the implication of a stimulus-response theory. If situation A arouses the conditioned responses CRa, CRb, CRc, CRd, as reactions to the elements a, b, c, d, then situation B, composed of elements a, x, c, y, will evoke the elements CRa, CRc, and will require less training than a totally new situation. Observation does not fulfill the prediction in many cases, however, for the elements x and y may inhibit the responses to a and c (Pavlov's external inhibition). The subject may fail to "see" a and c if they are bound within a strange figure (Koffka's "embeddedness"). Moreover, CRa and CRc may be totally irrelevant to the demands of situation B, and hence—even if they were to appear—would serve as a handicap. Thus, the Latin meanings of the roots embedded in our English vocabulary are all too often irrelevant to the demands of modern usage; modern English develops its meanings in a modern context.

There is, therefore, no possible way of predicting the usefulness of a particular type of training for a particular (other) performance, merely by counting identical elements. In fact, there is no known logic which will at the moment solve the problem; the relationship must be measured. When we have advanced a sufficient distance in this direction it will be time to speak of "laws of transfer."

The Role of Experience in Reasoning

Statement of the Problem.—We spoke of reasoning as the application of past experience to present situations that are partly old and partly new; and the concept of reorganization, discussed earlier, attempted to describe how this takes place. Perceptually, the situation before the reasoner takes on new form and meaning; behaviorially, a new organization of movement arises.

How are these new meanings and behavior patterns determined? Shall we view them as arising out of the dynamic "here and now" that includes both organism and the external configuration in one interacting whole? Shall we view the redistribution of traces as a dynamic process corresponding to the distribution of water particles in a whirlpool? Or shall we view the totality which emerges (the solution) as something composed of "elements" which were set up by past conditionings and here evoked by stimuli similar to those at work in the former situations? If we choose the latter description, the actions of the reasoner seem essentially "past-determined" and the laws of conditioning, association, and habit formation will play a

leading role in our analysis of the process. If we choose the former description, the role of experience will seem to be a minor one and the "dynamic" views of the Gestaltist will occupy the foreground.

Here, then, are two emphases—and a question. Which offers the best insight? Is reasoning primarily a dynamic process determined *on the spot*, or is it—like habit—merely a rehearsal, in a new setting, of old stimulus-response connections?

Now from one angle the work of the reasoner seems to be the very antithesis of habit. Habit is blind, mechanical. We speak of the "creatures" of habit, of "slaves" of a habit, and we have a low estimate of "routine minds." One variety of humor (which exalts our own feeling of importance) consists in showing an intelligence supposedly simpler than our own striving to meet a situation with an habitual, inflexible (and far too simple) set of stereotypes. The comedy founded on mistaken identity is of the same order. The intelligent reasoner, on the other hand, adapts and reorganizes his behavior. He spots the novel aspects of the situation before him, and includes them in his "structuring" of the situation. His behavior is, as a consequence, flexible, pliant, and highly adaptive. There is between these two types a difference like that between a great artist and an inferior cartoonist with a limited set of stereotypes. The latter in turn is like the logic-chopping dogmatist who must cut every problem to fit his rigid categories.

James's Description of the Process.—William James, who recognized (and in fact emphasized) this distinction, was inclined nevertheless to favor the habit analysis of the reasoning process. Whether our solutions are intelligent or mechanical, whether we possess the requisite novel adjustments or mechanically endeavor to apply old formulas, our solutions can come from but one source. Even when our wit is like that of the punster, who is continually playing with meanings which irritate sober common sense, we are drawing upon our fund of experience. The crux of the matter lies in the reasoner's ability to summon the *relevant* experience, in his ability to hit upon the *essence* of the problem situation. Of two research engineers working upon the same project, and possessing the same fund of knowledge, one may hit upon the solution, the other fail. The one who succeeds hits upon the *essence* of the problem, and discovering that, has a bridge which leads to the relevant knowledge.

Perceiving, James reminds us, is more than staring at a situation. We analyze it, break it up. (A Gestaltist would say we organize it,

"structure" it.) And in so doing we discover objects, qualities, aspects, meanings, which a moment before were nonexistent for us. And discovering such "elements" the situation (S) now has consequences, implications, properties (P). The essence (M) of the situation, which had hitherto escaped us, is the bridge whereby we cross to the solution—provided our experience has taught us that M is P. As soon as we see our present problem as an M situation we have the solution.*

To be a good reasoner, then, it would seem necessary to have a stock of knowledge, for it is from this source that we must draw our "M is P." The scientist who is fertile in hypothesis will be the one who is familiar with all the techniques, hypotheses, afloat in his own and related fields. But more than that, he will have to possess the rarer quality "sagacity," for it is in this latter trait, according to James, that the essence-selecting ability lies.

Before examining James's notion of this trait—which is a possession of the reasoner (and not of the dynamic situations of the Gestaltist)—we will do well to note the character of this "essence" of which James speaks. Every reality, James reminds us, "has an infinity of aspects or properties." The ruler lying on my desk is a measuring instrument, a straightedge, a hardwood product. It would be rigid enough to support a window whose sash weights were not working properly, or it might serve as a missile to drive away the neighbor's cat whose howling disturbs my studies. When one begins to consider the possible situations in which it might function, this ruler seems an almost inexhaustible "wellspring of properties." Every relation to other objects that it may enjoy becomes a property too: thus, its length (or its shortness), its ease of detachment from the desk, its inedible quality, and the fact that it is old, slightly warped (and probably shrunken)—and a seemingly endless list of traits, qualities, relations may be added. Of all the relations, that which it bears to the reasoner and his purposes is of primary importance for the problem of reasoning, as James outlines it. The essence of this object will vary with the reasoner's purpose; and the problem solver will deal with the object as though all other qualities, and relations, were nonexistent.

In this neglect lies much of the reasoner's efficiency. Without it his thought could not move. He can no more reason with an "infinity of aspects" than he can manipulate the universe. Without this power of abstraction he would either be like a child staring

fixedly at a bauble or like a mystic communing with the infinite; or, if he could grasp but one aspect of the situation, he would be like an automaton condemned forever to repeat one routine act. But it is equally true that the value of the abstracting process is conditional. *If* the neglected aspects are indeed irrelevant to his problem and *if* the implications of the essence (M is P) learned on another occasion are actually of value here, the solution may be achieved (and later verified).

At this point James returns to his trait, sagacity, for it is by virtue of sagacity that the successful reasoner selects the trait needed for his purposes. On the face of it, we are here reasoning in a circle. Sagacity enables us to select the right essence; but what, apart from this essence-selecting character is sagacity?

In his analysis James suggests three points: experience, interests, and association by similarity. Consider experience first. The ability to see anything in a situation, to "see into" it at all, demands experience. The new employee in the woodworking shop perceives little but a vague and disordered confusion. The din of gang saws, sanders, molding machines, is mingled with visual impressions of moving trucks, piles of lumber, the smells of sawdust, machine oil, and burning wood, and with tactual and kinesthetic impressions from vibrating floor, dusty surfaces, etc. As the weeks go by the structure of the industrial process becomes clear, the sequences in the manufacturing process emerge, and at any moment he can see what is "on foot." Or, to borrow James's illustration, the novice who thinks of a caterpillar as "nothing but skin and squash" is surprised to see the details revealed by a careful dissection. When the habit equipment of the individual is at the "skin and squash" level, he cannot be expected to achieve a sagacious analysis of his problems.

As for the second factor, interest, it is our interests, both practical and aesthetic, which force us to discriminate in the first place. In what we have discussed as the problems of motivation and attention James finds the explanation for the original dissociation upon which our stock of essences rests. To quote:

> The infant notices the candle-flame or the window, and ignores the rest of the room, because those objects give him a vivid pleasure. So, the country boy dissociates the blackberry, the chestnut, and the wintergreen, from the vague mass of other shrubs and trees, for their practical uses, and the savage is delighted with the beads, the bits of looking-glass, brought by an exploring vessel, and gives no heed to the features of the

vessel itself, which is too much beyond his sphere. These aesthetic and practical interests, then, are the weightiest factors in making particular ingredients stand out in high relief. What they lay their accent on, that we notice; but what they are in themselves, we cannot say. We must content ourselves here with simply accepting them as irreducible ultimate factors in determining the way our knowledge grows.[1]

The modern treatment of these "irreducible ultimates" would push beyond them to their biosocial roots. On the one hand, there are the instinctive and emotional capacities of the individual, his sensorimotor equipment; on the other hand, the social matrix which gives shape to these capacities. There is a physiological mechanism which centers the attention of the hungry boy, tramping over the countryside, upon the berrybushes; and there is a whole background of social conditioning which makes the savage's avidity for bits of beads and glass strike the shrewd Yankee tradesman as the most significant fact. The traits of the savage which are relevant to the purposes of this business agent of a New England community may be quite inadequate for the purposes of the anthropologist. If our interest, purposes, and background of experience are extremely narrow, we shall be able to dissociate but few characters from the objects and situations which confront us; and in this sense our sagacity is limited. We may display a sharp and lively wit within a narrow range of problems and purpose; beyond this field we shall appear stupid rather than sagacious.

The Factor of "Similarity."—In the third factor, association by similarity, James points out an additional role played by experience in the abstracting process. Consider the method to which most of us would resort if we were trying to get a novice to see a point, abstract a quality. Take the case of the child who has not yet achieved the concept of number or color. If we were trying to teach him the number "three" we would arrange three dolls, three blocks, three oranges, and painstakingly get the child to run through the number names, one, two three, with each collection until he could give us the unerring answer "Three" to our question "How many?" We would hope that he would see something about our collections, common to all of them, and we feel sure that, if we have not set a problem that is beyond his age level, the mere repetition

[1] From James, William. *Principles of psychology*, Vol. II, p. 345. New York: Holt, 1890. Reprinted by permission of the publishers.

of our varying illustrations will somehow free the element in question from the matrix within which it is embedded.

When we first ask the child "What color is that?" our question might well be "What is that?" for his reply (doll, dress, candy, block) will depend upon the color-bearing object; he may even name some gesture of the questioner. Ogden and Richards[1] describe a missionary to the Congo cannibals who faced a similar dilemma. The questioner wanted a word for "table," and addressed a group of boys standing near by. Tapping the table, he demanded, "What is this?"

"One boy said it was a *dodela*, another that it was an *etanda*, a third stated that it was a *bokali*, a fourth that it was *clamba*, and a fifth said it was *meza*."

The variety of responses might be taken to indicate the richness of cannibal language, a certain obtuseness in his hearers, or a delight in misleading and confusing foreigners who act in a superior manner. But the missionary discovered that, in fact, one boy had given him the word for *tapping*, another had given the name of the *material* of which the table was made, and the others had selected *hardness*, the table *covering*, and *table*, as the essences of the situation.

But if we vary our instances, keeping the essential item constant, we expect this element to "pop out." So the scientist may arrange his cases before him, letting his eye play over them, and as though he were taking a composite photograph, their divergence will retreat and the common element will detach itself, stand forth. Such, at any rate, is the process as James describes it, and common practice seems to verify the procedure. The comparison, the shift back and forth, causes the desired trait to "roll out" and "strike the mind."

Now chance contiguities will do something by way of providing the conditions for abstraction, but to a very limited extent. And if we were limited to present (or revived) contiguities our sagacity would be of a very low order. We are not so limited, however. The present situation invokes a row of "similars" and these memories will provide the varying list of illustrations. The M, which is embedded in the present situation so that it is not easily detached, "rolls out" when these similars are evoked.

[1] Ogden, C. K., and Richards, I. A. *Meaning of meaning*, p. 77. New York: Harcourt, 1923. Reprinted by permission of the publishers.

Abstractly stated, when the present problem situation is viewed against the background of those similar past situations which it calls up, the present situation is altered in such a way that its essence, previously obscure, is now apparent (cf. Fig. 105).

The sagacity of the genius (and the essence of the reasoning process) is thus seen as lying in a wide experience, in rich and varied interests, in the power of evoking a wide range of "similars." The stupidity of the habit-bound mind lies in its slavery to the contiguity factor, in the narrowness of its reverberations, and in its

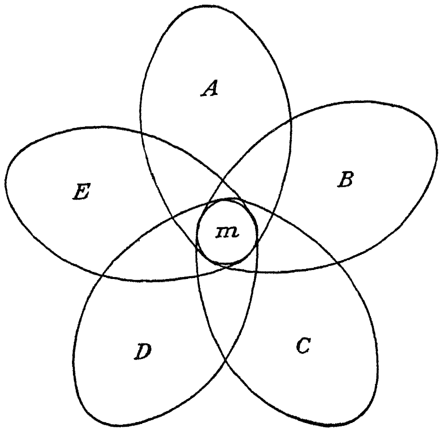


FIG. 105.—Figure used by James to illustrate association by similarity. *A*, the present representation containing the element *m*. *B*, *C*, *D*, and *E*, similar to *A* in that each contains *m*. James believed that the rapid evocation of these similars would cause *m* to "roll out," *i.e.*, to become dissociated from its varying concomitants. (*From William James. Psychology, p.* 366. *New York: Holt,* 1892.)

limited motivation. Comparing man to the brutes, James says of the latter:

They are enslaved to routine, to cut-and-dried thinking; and if the most prosaic of human beings could be transported into his dog's mind, he would be appalled at the utter absence of fancy which reigns there. Thoughts will not be found to call up their similars, but only their habitual successors. Sunsets will not suggest heroes' deaths, but suppertime. This is why man is the only metaphysical animal. To wonder why the universe should be as it is presupposes the notion of its being different, and a brute, which never reduces the actual to fluidity by breaking up its literal sequences in his imagination, can never form such a notion. He takes the world simply for granted, and never wonders at it at all.[1]

[1] From James, *op. cit.*, Vol. II, p. 353. Reprinted by permission of the publishers.

The Gestalt View.—While it would be incorrect to say that Gestalt psychology denies that experience plays a part in reasoning, this view does tend to minimize this factor and to find the significant determiners of the process within a dynamic present. Although it grants to experience the subordinate role of supplying a necessary minimum of raw material, it is the configurational aspect of the present situation that is all-important. Rather than viewing the reasoner as an analyst who breaks up the present situation into bits, some one of which will revive an old solution, the Gestaltist chooses to view the present situation as a dynamic totality, the solution as a new organization. In fact, the Gestaltist points out that the resemblance between the present situation and the one that functioned in the past may not be noted by the reasoner, although his solution be correct. In any case, he argues, how can the *similarity* between the present solution and an old one be noted until *after* there is an *insight* into the present problems? Experience, in other words, will not be relevant until we have diagnosed the present situation. In fact, it will never occur to us. And if these arguments are wholly valid, does not the essence of the reasoning process lie somewhere else than in experience, associations, traces, habits; does not its explanation lie within the dynamic present?

The Experimental Study of Reasoning. THE ROLE OF "DIRECTION."—An experiment by N. R. F. Maier bears upon this question. He presented to his subjects a task which demanded the use of three devices, or principles. To some of his subjects he gave a demonstration of these principles, and to others he merely gave the main experimental task; and there proved to be no significant difference in the two types of performance. Fifteen subjects who were not given the "experiences" failed to solve the problem, but so did 36 out of 37 subjects who had been given a demonstration of the principles. Twenty-eight of those receiving the demonstration had already been told of the nature of the experimental task, and knew in addition that the "experiences" were relevant. In spite of this, but one person was able to make use of the demonstrations.[1]

A brief description of the problem and the demonstrations will be necessary before we pursue an analysis of Maier's results. The subjects were admitted, one at a time, to a lowceilinged (*ca.* 2 m. in height) room containing chair, table, 4 poles, table clamps, burette clamps, lead tubing (or bolts), 2 pieces of electric bell wire,

[1] Maier, N. R. F. Reasoning in humans. I. On Direction. *J. comp. Psychol.*, 1930, 10, 115–143.

chalk. The subject's attention was called to two chalk marks upon the floor, and he was asked to construct two pendulums from the materials in the room, each one so fashioned that it would carry a piece of chalk that would make a mark at the points indicated upon

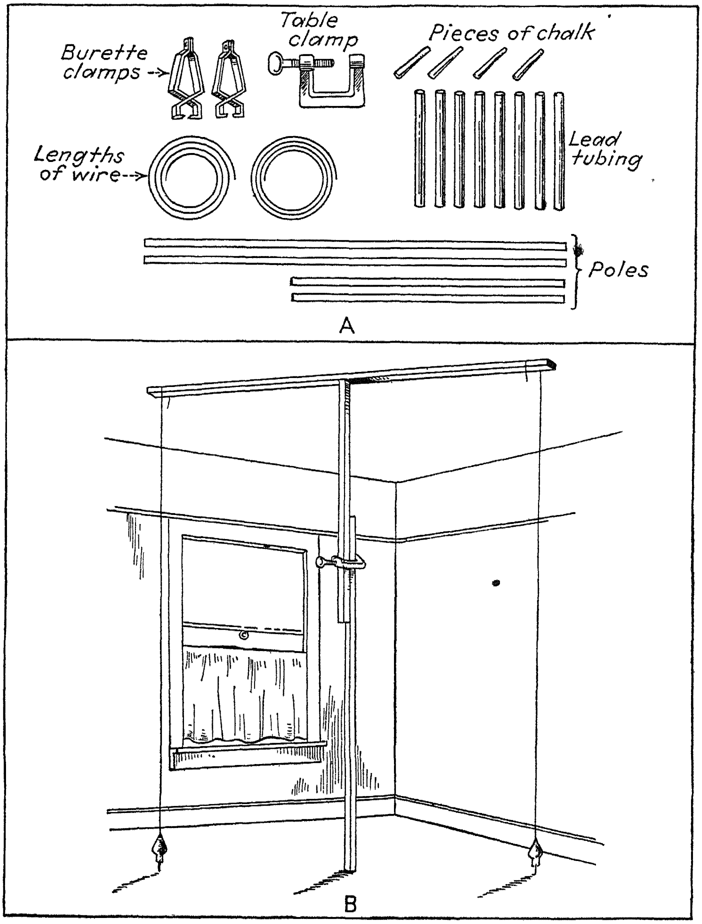


FIG. 106.—The pendulum problem. (*From L. W. Crafts, T. C. Schneirla, Elsa E. Robinson, and R. W. Gilbert. Recent experiments in psychology, p.* 348.)

the floor. The subjects were cautioned neither to move the table nor to make the chair a part of the final construction. As to how they were to fashion and hang the pendulum, that was up to the subjects.

The three demonstrations showed the subjects (1) how to make a plumb line, (2) how to reach an object farther away than the longest poles, and (3) how to make a construction without a hammer and nails. In the first demonstration a burette clamp, pencil, and wire were combined before the subject. In the second, the subject was shown how two poles could be fastened together with the table clamp to make the desired tool. The third demonstration was more complicated and is given in the experimenter's own words:

Now I will show you a way to do without hammer and nails. If, for instance, you wanted to make a lantern screen, you naturally would like to have nails with which to fasten the screen to the wall. If there are none to be had you could take these two poles, place one flat against the wall of the doorway, like this, and so keep your white cloth taut up and down, then place this stick at right angles to it and wedge it in the doorway. (This was demonstrated by placing one of the sticks against the side of the doorway and wedging the other against the center of the first and the opposite wall of the doorway. Thus a "T" in a horizontal position was formed.) In the same way you could fasten the other side of the screen and so keep the cloth taut sideways. Thus we could do it without hammer and nails. Do you see?[1]

In spite of the demonstrations, 36 out of 37 "advanced students" failed to achieve the correct solution which consisted in wedging one of the long poles against the ceiling, using two poles clamped together for the supporting wedge. Properly placed, the long pole permitted the wires for the two pendulums to hang over the two chalk marks, thus fulfilling the task. The pendulum construction itself gave little difficulty.

The performance of the subjects changed radically when a "direction" was added to the instructions. To some subjects the experimenter said:

"I should like to have you appreciate how simple this problem would be if we could just hang the pendulums from a nail in the ceiling. Of course, that is not a possible solution but I just want you to appreciate how simple the problem would be if that were possible. Now that it is not possible, the problem is, as you may find, really quite difficult." This was demonstrated by holding one of the wires against the ceiling.[2]

[1] *Ibid.*, p. 119. Reprinted by permission of Williams & Wilkins Company, publishers.

[2] *Ibid.*, pp. 119–120. Reprinted by permission of the publishers.

When both the experiences and the direction were given to 22 subjects, 8 were able to make the desired construction (an increase from less than 3 per cent to 36 per cent), and 4 of the remaining 14 tried unsuccessfully to use the ceiling. (In the "nondirection" groups but two had attempted to use it.)

"Direction" and Experience.—Maier's experiment does not, however, make out a complete case against the efficacy of experience. Ten subjects, for example, were given the direction *without the experiences* and none of them could solve the problem. Neither experience nor direction, operating alone, proves sufficient. What the direction ensures is a proper "mode of conceiving," a proper diagnosis of the difficulty. Once the subject is brought to see the problem as one of "hanging a pendulum from the ceiling without hammer and nails" the experiences can function.

Maier found, too, that once a faulty direction had been established by a subject, further hints were of little help. They tried, rather, to fit them into this faulty pattern. But once the subjects were oriented ceilingward, the hints were useful. With a false orientation there was a persistent and stubborn attempt to warp every hint to the false direction. The direction thus serves as a framework within which a succession of trials is carried on. It is comparable to the set introduced by the instructions in a controlled association experiment (*e.g.*, "give opposites"). Behaviorally, it functions as a controlling posture, facilitating the rise of congruent activities and blocking others. It is more than a bridge to other experiences, for one of Maier's groups had the experiences, and some had been warned of their applicability, and they were such recent events that there was no question of forgetting involved. It is here not a case of remembering, but a case of being able to utilize the experiences, and with faulty direction (orientation, posture, set) the experiences do not point to the solution. The context in which they arise neutralizes them and renders them valueless. Thus the initial error of a false start or diagnosis is compounded at each stage of thinking.

In this connection it is worth emphasizing that, although two subjects may work in the same objective situation (room, clamps, poles, etc.) and under the same verbal directions ("build a structure from which two pendulums can be hung"), they may nevertheless be engaged in different tasks. One, starting from the large and stable table, tries to build a support on this base, clamping a long

pole to the tabletop (but finds the support too flexible); another starts from the ground up, building a "hatrack" structure (but runs short of materials). With either of these schemes as a base, the demonstrations are not utilized. In fact, they are to a considerable extent irrelevant.

And not only do the initial attempts and diagnoses differ; each is a developing thing. The "too-wobbly" table construction becomes a search for a "stabilizer," the paucity of materials in the "hatrack" construction becomes a "material-saving," or "ersatz," problem. In all this we have something akin to trial and error, but it is a trial and error confined within the directional framework, and a trial and error which develops as it changes. For all the variability which a subject shows, he seems strangely bound within the directional framework. And when the correct direction had been established, the solution came rapidly, frequently in one flash. This fact, coupled with the vast amount of blundering when faulty direction had been taken, argues against the adequacy of any purely trial-and-error description of the reasoning process.

All this is, however, far from a dismissal of experience. Although Maier describes the demonstrations as part *A*, part *B*, and part *C*, and calls the "direction" by a different name, it might just as appropriately be called part *D*, and given an equivalent rating with the other demonstrations. What makes it unique is that without it the other experiences do not function. None of the habit theories would deny, I believe, that some experiences are more important than others. In an uncontrolled problem situation we should look upon the just-preceding events, the motivation, as providing the "direction"; the whole body of experience provides the materials of his thought. What Maier has shown is the importance of this direction of approach, and the powerlessness of the objective (external) situation, association bonds, relevant experiences, mechanically to forge a solution when no fruitful hypothesis (line of attack) is present.

But of what advantage is it to the reasoner to know that he may possess the relevant experiences and—though he try persistently—still fail to achieve a solution? Is he not left at the sport of chance? Will he not have to accept the "directions" which circumstances conspire to give him with "natural piety"? Is there anything for him to do but persist, blunder, and wait until his attitude has shifted, or until he is more favorably placed, or until some chance event,

suggestion, circumstance, releases the response around which his relevant knowledge may crystallize?

IMPROVING THE EFFICIENCY OF THE REASONER.—In a second experiment[1] Maier tried to see what could be done to help the reasoner over this difficulty. Three hundred and eighty-four subjects worked at reasoning problems. Half of them were given a 20-min. lecture which described the reasoning process, and stressed three points:

1. The importance of locating and defining the difficulty. It was pointed out that this diagnosis determined what one does, and that persistent failures pointed to the necessity of getting a false direction completely out of one's mind.
2. The importance of keeping out of the ruts of habit, of keeping the mind open for a fresh line of attack.
3. The solution typically appears suddenly. It cannot be forced. What one can do is to avoid wasting time on a line of endeavor that has proved unprofitable

When the lecture group was compared with the control group, it was found to have achieved distinctly superior scores (49.2 per cent of the problems as against 39.7 per cent). Maier advances these facts as an indication that "reasoning is, at least in part, the overcoming or inhibiting of habitual responses." The faulty direction, whose persistence inhibits the solution is thus attributed to habit, although if the latter is made to bear the onus of failures it might also be credited with those cases where an "insight" provides the basis for a rapid reorganization of experience. As for the hygiene of the process, in view of the limited amount of instruction it would seem that a relatively modest amount of properly directed training—where attention is paid to such an inertia factor—markedly improves the reasoner's performance.

HINTS WHICH "PRECIPITATE" THE SOLUTION.—A third study[2] by the same experimenter throws additional light upon the insight process itself. In this experiment Maier presented his subjects with a problem which could be solved in several ways, one of which (a less obvious method) he counted more original, and in this solution his interest centered. The subjects were brought into a large room containing tables, chairs, poles, ring stands, clamps, pliers, and extension cords. Two cords hung from the ceiling to the floor,

[1] Maier, N. R. F. An aspect of human reasoning. *Brit. J. Psychol.*, 1933, 24, 144–155.

[2] Maier, N. R. F. Reasoning in humans. II. The solution of a problem and its appearance in consciousness. *J. comp. Psychol.*, 1931, 12, 181–194.

one from the center of the room, the other near a wall. The subject was given the problem of tying the two ends of the strings together; and since he found that in holding one cord he could not reach the other, some construction or reorganization was called for. When he had found one of the easier solutions he was urged to do it again "in a different way." Failing to reach the most difficult solution, "helps" were given. When the difficult solution appeared the subject was questioned as to what was "in his mind" before the solution came, as to how the solution appeared, and as to what suggested the idea.

The solution which Maier was interested in consisted in tying a weight (*e.g.*, pliers) to the center cord and then setting it swinging. Thus, if the other cord was brought near the swinging cord, the latter could be caught, and the two ends tied. The two hints consisted in:

1. The experimenter, in walking across the room, sets the cords in motion. (The subject is unaware that a hint is being given.)
2. If hint 1 fails, the subject is handed a pair of pliers and told, "With the aid of this and no other object there is another way of solving the problem."
3. If hint 2 likewise fails, hint 1 is repeated. If this also fails, the solution is then demonstrated.

Of 61 subjects 14 failed entirely, 23 solved it with the aid of "helps," 24 solved it without such aid. In the groups solving with "helps" at least 10 min. were allowed to lapse before the first hint was given and the average lapse of time between the hint and the solution was 42 sec. Clearly, the hint "precipitated" the solution. In 16 of the 23 cases it appeared suddenly, in full bloom, yet but one subject recognized that hint 1 had helped him. This subject stated "that he noticed the cord sway and thought that perhaps it suggested the solution." Of the remaining 7 the solutions appeared in parts: the swaying was noted, and credited with shaping the problem (the subject then thought of making it sway harder), and only later was the idea of the weight added.

Thus it would appear that "insights" are of different degrees of completeness, that they may appear in full bloom, or develop progressively stage by stage. It appears, too, that where the partial solution appears, and behavior remains suspended at a halfway stage, the subject is more likely to isolate and identify the factor responsible for this fragmentary "insight." On the other hand, when the complete reorganization occurs with the suddenness of a

reversal in perspective (or finding the hidden face in a puzzle picture) such analysis and identification may not occur.

As in his other studies, Maier notes a marked perseverative tendency. Previous solutions tend to persist. When helps are given they tend to be incorporated within the prevailing direction. Thus, among those who failed, the presented pliers suggested "tongs," and longer ones were wished for. The weight of the pliers did not strike them as an important "essence," to use the term of James.

Situation and Diagnosis.—While there is much in the subjects' behavior that resembles the trial-and-error performance of animals, Maier does not believe that this is a significant description. What a subject does is best understood in the light of his diagnosis of the difficulty. Although the external physical conditions are the same for all subjects, the problem-as-conceived varies. The subject may desire:

1. To make one cord stay near the center while the other is reached. (Thus he will try to anchor it to some heavy object—(*e.g.*, chair, placed midway between the cords.)
2. To lengthen a cord. (This was done by attaching an extension cord.)
3. To lengthen his reach (*e.g.*, with a pole).
4. To make one cord move toward the other (as in the difficult solution).

The solution formula is thus viewed as arising out of the diagnosis. The "arm-too-short" diagnosis produces "lengthen the arm." The "cord-too-short" diagnosis is the origin of the "extension-cord" solution. Reasoning is thus fundamentally a question of perceiving. As in the Gestalt view of learning (and, although these experiments are described as concerned with reasoning, it is difficult to establish a boundary line), the situation takes shape under the stress of a felt want; the reasoner experiences the problem as an all-but-complete figure which calls for "closure." Just as a suddenly abbreviated melody or rhythm incites us to complete the figure, the problem situation is a field of stress whose dynamic properties produce the solution.

Like the "find-the-face" puzzle, slight changes may precipitate the solution. Or as in drawing a figure, the chalk artist may withhold the key strokes until the last, and a single item then gives the "Aha" of insight. So the movement of the cord has ushered in the "pendulum" figure. The precipitating item need not be "noticed" (*i.e.*, discriminated or isolated in such a way that it can

later be reported upon) any more than double images are noted in depth perception. While we stare at the reversible perspective figure it "flops" before our eyes, and we do not spot any cue that is causal nor can we analyze out a number of stages in the transition. Similarly, the problem-as-conceived changes for the reasoner; here, however, it is a case of "multiple perspective."

Awareness and Similarity.—One is struck, I think, by the extent to which these processes function outside of any discriminating awareness. Though marvelously complex and adaptive, they are not at all the products of any conscious process of fitting together elements into a structure. One is reminded of the way in which a blindfolded person continuously and automatically is able to keep track of his starting point as he walks about a room. He is not a surveyor, carrying on a step-by-step "triangulation"; at any moment our question will release the appropriate pointing (with a margin of error, to be sure). So, too, the localizing forearm, in tactual space localization, may rest poised above the surface of the forearm, quite unable (without contact) to make any correction. Yet in one sense the subject is correct if he says that he "knows" more than the localizing posture reveals, for as soon as his stylus touches the skin surface the new touch rises into consciousness charged with a relation. So the reasoner exploring a field of objects somehow accumulates and compounds his trials so that when the significant element is struck it enters and fuses with this compounded whole.

In connection with the "association-by-similarity" explanation of reasoning (James), Maier affirms the general Gestalt position, arguing:

1. That similar solutions may easily interfere (cf. "persistence of direction").
2. That a "problem which is different from one solved in the past, but which has the same principle involved in the solution, cannot have its solution explained by similarity because there is no similarity until both solutions are known. When the solutions of such problems are explained by the principle of similarity the explanation seems to be nothing other than rationalization."[1]

However, in view of the extent to which Maier himself has demonstrated that these processes function outside of awareness, one wonders whether we may not speak of an "objective similarity" which may function whether the subject has succeeded in isolating and noting it or not. Thus, with human subjects who are able to introspect, the tracing of two mazes of different sizes but identical

[1] *Ibid.* Reprinted by permission of Williams & Wilkins Company, publishers.

ratios clearly shows a transfer effect whether the similarity of the two mazes is noted or not. In the same manner, may not the similar (yet different) past experience operate in orienting the reasoner toward the solution, facilitating the appearance of "insight" even though the verbal reports of the reasoner fail to reveal this factor? The earlier discussion of the extent to which "unconscious sets" do so operate should not make such an hypothesis seem beyond belief. The question really calls for objective measurement.

It is true that in Maier's earlier experiment, where the parts *A*, *B*, and *C*, containing three principles involved in the solution of a composite problem, *ABC*, were known in advance, these "similars" proved insufficient to bring about a solution. That the similars were insufficiently related to the solution seems demonstrated by the subjects' ready recognition of the point of the hints once the solution was shown to those who had failed, by their surprise "at their 'dumbness,'" and their inability to "explain why they hadn't done it themselves." Clearly there are similars which do not produce insight.

But there is no logical reason why Maier's "direction" should not also be called a similar. Standing on a chair and pointing the subject's attention ceilingward is as much a similar as showing the subject how to build a plumb line. The force of Maier's experiment must lie, therefore, not in any denial of "past determination" or of the value of similar experiences; but in its stress upon the critical or crucial character of a few of these. Without the ceiling-orienting "similar experience" all other similars remain nonfunctional. But it proved equally true that with the ceiling-orienting experience alone (and without the other similars) no solution appeared. It is to Maier's great credit that he has so neatly demonstrated this directional factor. Clearly, we can no longer look upon the reasoning process as a mere automatic revival of similars. The attitudinal and directional factor (which itself may be one of the similars) deserves especial emphasis in any account of reasoning.

Once there has been penetration into the problem, once there has been an insight into the difficulty (too short, too long, too fast, etc.), once the conflict is located and diagnosed, then old traces may operate. When I have reached the stage of "something to lengthen my arm" (cf. Köhler's ape) I proceed to cast about among my experiences as well as among those objects visibly present. (Tschego dashes for her blanket.) Like one who is looking for a "something-

to-prop-up-a-window" or a "something-to-hit-a-nail," the reasoner has an all-but-complete posture. We have all seen that incipient hammering gesture, and the quick grasp of rock, hairbrush, or whatever lies at hand. Like an all-but-complete rhythm, the demand-for-closure is insistent, and highly selective.

If this analysis of the reasoning process is correct, then we have new light upon the "transfer" problem. Not identical elements, but identical configurations, are the limiting factors. But there is another limiting factor. Even where there are relevant configurations, even where past experience contains "insights" which might be used in the present situation, they cannot become functional before the present situation has been comprehended (penetrated) and the significant functional relationships laid bare. If the "direction" originally taken by the reasoner in the present situation is the wrong one, if the significant relation is "embedded" and obscure, if one's habitual trends in the problem situation lie counter to the correct direction—then, although one possesses the requisite experience and although there are abundant identical elements, the solution does not emerge. Education can supply valuable materials, but it can neither guarantee nor predict their functioning at some given time and place in the future unless these additional items are controlled. It is in this sense that it seems necessary to follow the Gestalt emphasis upon a dynamic present.

The Insight Process

Locating the Problem.—In learning, perception, and reasoning we have repeatedly met the insight process. In learning it appears as a sudden solution; in perception it appears as the organizing principle which produces figure-ground relations (and thus yields the "object" and its field); and in reasoning it appears first as the hypothesis—the guiding line in terms of which the situation is organized—and finally as the completed organization which "clicks," comparable to the solution of the learner. At best, however, it is a rough description, and so long as the intimate character of the process remains an enigma the psychological task remains incomplete.

For the most part we have but located and defined the problem. We say that insights come to those who approach a situation with questions (and then only when the right direction is pursued); we show that experience is necessary, but that the present organization is new; we describe the process as a sudden perception of relations,

or as the closure of a previously incomplete figure; but these characterizations of the process do little more than point out the direction along which future investigation must proceed.

We do not advance matters by attributing these insights to intelligence, sagacity, or reasoning ability, or to observation, comprehension, attention, or any other general function which may be named as basic. Our hope lies rather in the further analysis of its determinants, in the "essential" relations, for when we know these we gain a measure of control over the process and some comprehension of its structure. One fact seems clear. It is not the kind of process to which introspective studies can add much. At one moment there is no insight. The questioning observer is puzzled, his eye roves to and fro across the problem situation. And then it pops! It may come without warning; it may be precipitated by cues of which the subject is unaware. Only objective studies can reveal these.

Neither can we follow the Gestalt emphasis upon the present dynamic situation all the way. While in one sense all the "forces" are present (the organism with its intention, question, goal, motivation, and its system of traces, on the one hand; the constellation of external stimuli which confronts the reasoner, on the other), if we are interested in the practical problem of producing insight (*e.g.*, all publicists and educators are), this view is inadequate. For experience plays a role. There is the immediate past which delivers to us an organism already oriented, and the remote past with its similars which provide the present organism with the raw materials to be reworked. The implications of present stimuli, the very grasp of the problem, the forecast of the line along which the solution will arise—as well as the solution itself—must all be viewed as a fusion of present and past determinants.

One stress on the motivation side of the problem is clear. The more sharply defined the orientation the more complete the comprehension of the problem—the greater the likelihood of insight. Thus the insight type of solution lies at the opposite pole from trial-and-error learning, where motivation seems more of a push than a definite orientation. Insightful behavior is guided more by the "sense" of the situation than by a mere aggregate of stimuli, and the successive stages are more a matter of progressive penetration, grasp, comprehension of relations, than a succession of isolated stimulus-response units, each on a par with its predecessors. As

the reasoner proceeds, the circle within which blundering occurs grows narrower. Thus, motivation is progressively sharpened, oriented.

The Role of Exploratory Trials: the Schema.—Insightful learning (or reasoning) does not dispense with trials. It is, rather, that the trials have here acquired some added function. In fact, it is by this weaving to and fro in the reasoning situation that the progressive penetration is made. Like a spider weaving a web, the reasoner builds up a network of relations until, having explored the problem situation fully, he has somehow incorporated it. Exploration has constructed an internal manipulable model. The stages of his exploration are cumulative, the last move comes upon the accumulated background of the compounded preceding trials. It is for this reason that the stimulus which we first ignored as of no significance may prove—when later we meet it—to be the figure-closing link in an all-but-complete action. Out of the weaving to and fro arise the relations; these do not become dynamic until they have become incorporated.

In a study of this process, by Claparède,[1] the subject was given the task of finding a suitable caption for a cartoon. He searches the drawing, looking for a "lead." As he catches the comic note, his task is sharpened. He searches the expression on the woman's face and her shrewish expression throws his glance toward the object of her displeasure. Thus his insight is developed. The question with which he started alters as his exploration yields partial answers and at the same time raises new questions. This developing "question-and-answer" process proceeds until the last stage when he achieves his final organization—one which releases the tension that started the process. This last step is a movement like all the others, and arises out of the same type of developing matrix. The fact that its function and value are different does not mean that it is of an entirely different order. If the final insight is mysterious, so are the preceding partial and faulty ones, so is every act of perception.

This "web-of-relations" which the reasoner's to-and-fro survey establishes is constantly with us, and when we reexamine the most common experiences, its operation is so patent that one is moved to discard entirely the notion of an environment as a mere aggregate

[1] Claparède, E. La Genèse de l'hypothèse. *Arch. Psychol., Genève,* 1934, 24, 1–155.

of stimuli. To illustrate: a mother who has left her child in a perambulator a few paces away while she makes a few purchases at a roadside market, reacts to the passing dog, the honk of the motorist—to every marked and sudden change in the environment—in relation to that child. Her repeated glances toward the child not only reassure her that all is well, but they serve to maintain and correct an orientation. Her posture constantly "keeps track of" the child—she has "incorporated" child and perambulator into her system of movements, and as she moves about each successive motion contains a corrected orientation, a preparation for instant return to that center of interest. Her dash for the perambulator at the sign of danger is no simple mechanically fixed reaction to a stimulus (*e.g.*, barking dog)—in fact, this particular web of relations in all probability never existed before; but by virtue of the schema[1] which she carries, every entering stimulus is charged with relations, and the response which issues is a resultant of a most complex interplay of forces.

An older psychology was inclined to place this schema, or web-of-relations, in the cerebral cortex. It spoke of mental attitudes, or sets, of apperceptive masses, in terms of either mind, or consciousness, or cortex—as though the head carried within it a small model of reality. From our study of physiology, however, we have seen no reason for placing this schema anywhere, save throughout the functioning organism. If the organism is to contain a microcosm, we might as well be as generous as possible and let this web-of-relations be written throughout—from top to toe.

Though experience has built the web, it is an ever-changing, developing thing, and each new stimulus leaves it slightly changed. When we note that the mother's first child has produced a fundamental change in her make-up (reorganizes her behavior) we shall be better able to account for her subsequent reactions in terms of such a developing schema than in terms of associations, synaptic bonds, similar situations, where every reaction to the child is to be explained in terms of past conditioning in identical situations. Without denying the facts of conditioning, without denying past determination, we are forced by our study of reasoning to look beyond them for a complete explanation.

The Frame of Reference.—This emphasis upon the *reality of relations*, the constant theme of the exponents of the Gestalt view-

[1] Cf. Head, H. *Studies in neurology*. London: Hodder and Stoughton, 1920.

point, may be approached from a different angle. Obviously, if we rearrange letters we produce words of new meaning (god–dog, bad–dab, ten–net). It is not the isolated letters that we respond to; the pattern must be considered. Similarly, over, under, before, after, etc., are important aspects of the stimulating situation, as important as the things related. All this is familiar, and obvious. It is also true that the frame within which an event occurs alters the stimulus value of the event even though considered as an "isolate" it is the same. Like a magnetic field, the frame, or context, pulls the event which is surrounded into new shapes. We can see how this is true in visual illusions, where, as in the Müller-Lyer illusion (see Fig. 107), the "wings" attached to the ends of the compared lines alter our judgments of their length, even though we intend to disregard them. So it was in Bartlett's study, when an Indian folk tale was made over into a British model—the context of stereotypes aroused by the material pulled it into a conventional pattern. So it would be if, in imagination, we were to transpose the familiar nursery rhymes of our childhood into the atmosphere of the night club. In our imagery "Little Boy Blue's horn" might easily become distorted in the direction of one of the instruments of the orchestra, his music take on another sort of "blue" quality, and the "boy" himself become a costumed entertainer. So, too, a Thomas Hardy matches the mood of sky and moor to the thoughts of his brooding character. While the reasoner who endeavors to grasp the stubborn facts before him may be less free to impose constructions, and while the physical relations before him are not so fluid as in the case of creative imagination, the same distorting influence of the frame—the same dynamic impulsion toward a fitting relationship between event and context—will be at work.

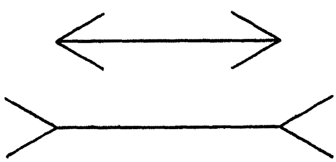


FIG. 107.—Muller-Lyer figure.

The direction—to which Maier called attention—is such a frame. As a definition or diagnosis of the problem it sets up a general schema into which the reasoner labors to fit the recalcitrant materials. Does he desire a weight-to-convert-a-string-into-a-pendulum? Then a pair of pliers can be used. Previously they had been pliers, too-short tongs (when the subject had been looking for a something-with-which-to-reach-an-object-at-a-distance).

From the examples which have been chosen it would appear possible to speak of two classes of "frames." On the one hand, there are the physical relationships of juxtaposition, continuity of line, identity (or contrast) of brightness, and color, etc., existent in the field (that is to say, for all observers). On the other hand, there is the subjective frame, the definition of the task, the constantly developing schema, supplied by the reasoning individual.

Looked at as behavior, the subject's "direction" is an *operation* (such as adding, cutting in two, drawing a ring around, etc.) which can be applied to an endless list of materials, grinding out new results as new raw materials are supplied. A rhythm once established can be filled in with a wide variety of melodies. Similarly a proportion, such as 2:4, can be supplemented with an infinite number of pairs of numbers which fulfill the demands set up by the first pair. We can understand the task of the reasoner facing a problem, in the light of these analogies, as twofold: (1) the discovery of the "operation" which is required (the direction) and (2) the application of this operation to the presented materials until a best fit, a solution, verification, or release is obtained.

An Example.—To illustrate: a ten-year-old boy is presented with the following equations:

$$2^2 = 4$$
$$3^2 = 9$$
$$4^2 = 16$$
$$5^2 = ?$$

He is told merely that these are read as "two squared equals four, three squared equals nine, etc.," and he is asked "What does 'squared' mean, and what number should we put in the place of the question mark?" His verbalization indicates that as he fixated the first equation he applied the addition formula "two and two." This promptly failed him at the next equation, for, pointing to it, he noted "But you'll have to take three." At this moment his "insight" appeared, for he promptly supplied (though questioningly) "Would it be 25?" When this was accepted and he was asked, "Then what does 'squared' mean?" his reply was prompt, "Times the same number."

Let us "introspect" for our subject, imagining what we would do in similar circumstances. Glancing at the equation $2^2 = 4$ we ask ourselves, "What does the little 2 do to the larger one, to make it

equal to 4? Obviously, it either adds a two or multiplies by two." And we know this because of specific training we have undergone. Out of alternate associates we shall have to select one, and the way we discover which "insight" is correct is by the cut-and-try method of applying each in turn to the other equations. Thus, in the present illustration we might apply the concepts of insight, trial and error, direction (as an operation), and the doctrine of "essences" (in the association theory of James). Are they not all present? And are we not, as psychologists, like the fabled blind men and the elephant? One of us is struck by the *novelty* of $5^2 = 25$, another by the *abruptness* of the perception which reduces 2^2 to 2×2, 3^2 to 3×3, etc., another by the fact that the operations which are applied would not appear but for *past training*, another by the importance of *relations*, another by the fact that the past experience does not function until the appropriate *direction* arises, etc. And are not these different emphases all true? And do they not comprise so many insights into the insight process? And will not the significance of each view be relevant to the purposes of the one who studies or deals with the reasoning process?

In thus returning to the doctrine of the relativity of essences, we have completed the circle, returning to James. His statement remains essentially true; the best we have done is to extend it by including the recent work of the Gestaltists, and by reopening the physiological problems which still remain very largely a mystery. What, physiologically, is the schema, and how are traces able to compound their effects, mutually transforming one another, adapting themselves to novel configurations, and yet somehow maintaining their identity? We are scarcely able to formulate these problems. Adequate answers seem to be far in the future.

Insight and Closure. *The Forward Reference of Perceptions.*—Incomplete figures tend toward completion. In a stable, recurring situation, this tendency will be regarded as the force of habit. Thus the familiar and all-but-complete visual diagram will invoke the missing part, the oft-repeated (but now interrupted) rhythm calls irresistibly for the concluding beats, the conventional sequence of chords calls for those which "resolve" our expectancies, etc.

But the tendency toward closure cannot be attributed solely to mechanically operating *S-R* bonds, to a redintegrative principle whose force and direction is derived wholly from previous constellations. Just as it is possible to derive new facts from the model

of a machine, once it is constructed, so our definition of a problem (direction) operating upon the presented materials is able to release new configurations. We say that we recognize the *implication* of the situation or that the facts point toward our solution. How clearly this "pointing" emerges depends upon the figure constructed, and the portion of the figure that is missing. The internal stresses of the figure will generate the missing part much as the plant or simpler organism regenerates a branch or limb.

Among the materials used by Claparède, in his study, is an incomplete joke. A child, for example, is described as asking his father, "Papa, does my teacher have the right to punish me for something I haven't done?" To this the father replies, "Certainly not, my son!" And then the youngster, "But that is just what happened, all the same. She punished me because I hadn't done . . . " and the solution characteristically appears at once, fully formed. This is no redintegration of a joke we have heard before, nor is it any automatic word association. It is true that our experience with schoolrooms and teachers may have built the "model" which makes the present completion possible, but once the model is built an endless series of "manipulations" will be possible, and for each unfinished "operation" there will be specific implications.

This forward reference, this reflection back into the stimulating situation, is indeed a primitive thing. We met it long ago in connection with motivation. Not only do we react to stimuli, but in reacting we transform their stimulus value. In releasing tensions we set up new ones. In perceiving the meaning of a situation we release impulsions. Diagnosis, "direction," impulsion, and implication, are thus bound in one process.

Configuration and Association.—In the illustration which we borrowed from Claparède we can see a fresh affirmation of the importance of relations. The associations of the successful reasoner operate at the level of comprehension, rather than at the simpler level of physiological reflexes. The idea which is called forth possesses a certain "fitness" and answers a need. By a kind of internal resonance the all-but-complete figure sets in vibration the completing link. Or, when it invokes a similar configuration the linkage is one of relations rather than of identical elements. Consider, for example, the connection between the ideas which follow:

A. In a pamphlet prepared for future citizens, and calculated to prevent any misinterpretation of the name of their organization,

and to combat "subversive influences" at the same time, the Daughters of the American Revolution state:

You will see from this that the American Revolution was not a revolution in the usual meaning of the word "revolution"; it was a *revolt* from England, a war for independence. A revolution usually means an attempt to tear down or overturn a government or wreck the existing institutions of a country. The American Revolution did none of these things; on the contrary, it was a war fought to PRESERVE the principles of the colonial government; it was fought to MAINTAIN the liberties of the colonists which George the Third had tried to take away. Americans abhor the kind of revolution which destroys and overturns, which murders, loots, and burns. This was not an attempt to destroy any government; on the contrary, it saved and built up the free governments the American colonists already had. The victory made them free to set up a national government for the whole country on the foundations already laid by the various colonial governments. It transformed the thirteen separate colonies into the United States of America under the constitution . . . [1]

B. Now note the type of "association" which is involved when the reading of the above passage immediately recalls the efforts of Dr. Lyman Abbott to reconcile current business practices with "The Ethical Teachings of Jesus."

My radical friend declares that the teachings of Jesus are not practicable, that we cannot carry them out in life, and that we do not pretend to do so. Jesus, he reminds us, said, "Lay not up for yourself treasures upon earth"; and Christians do universally lay up for themselves treasures upon earth; every man that owns a house and lot, or a share of stock in a corporation, or a life insurance policy, or money in a savings bank, has laid up for himself treasure upon earth. But Jesus did not say, "Lay not up for yourselves treasures upon earth." He said, "Lay not up for yourselves treasures upon earth *where moth and rust doth corrupt and where thieves break through and steal.*" And no sensible American does. Moth and rust do not get at Mr. Rockefeller's oil wells, nor at the Sugar Trust's sugar, and thieves do not often break through and steal a railway or an insurance company or a savings bank. What Jesus condemned was hoarding wealth.[2]

When the writer first read the D.A.R. pronunciamento on revolution, his thought immediately flashed to Dr. Abbott's rationalization

[1] From the D.A.R. Manual for Citizenship, 16th ed., pp. 12–13. Reprinted by permission.

[2] Abbott, Lyman. *Outlook*, 1910, 94, p. 576. Quoted by Upton Sinclair in his *Profits of religion*, p. 175. Long Beach, Calif.: Upton Sinclair, 1918.

of business enterprise. The two ideas had never been contiguous in space or time previously, nor were there specific word linkages (common elements); the arousal of the *B* passage occurred because of a certain formal identity, a similarity in social significance and a similarity in the type of thought process involved. It was the perception of the meaning and implication of the first which made the *B* trace available.

Logic and Psychology

To trace in full the relationships between logic and psychology is an undertaking far too vast for us here; but we may indicate, briefly, the problems which the student of psychology may do well to face.

The picture of the reasoning process which we have drawn may easily arouse a certain sense of disquietude, for it seems to make all reasoning a tentative, semi-intuitional process, and to lump together the work of the scientist and the creative artist. The insights of the one appear to be of the same order as those of the other. Where is the kind of thinking that has coercive power, that compels belief, that yields results which *must* be true? What of the canons of logic, and the truths of mathematics? What of "universal truths," and of the great body of scientific knowledge? Is there no clear path to certainty?

"Closed Systems" and Codified Experience.—Practically, we treat many issues as closed. Children and savages, who have but recently discovered the properties of number, may view them with a mixture of wonder and doubt; but for civilized adults the operations of counting, adding, multiplying are tedious, routine, mechanical tasks—so much so that, wherever we can, we delegate them to machines. We have machines that add, multiply, subtract, divide, integrate, correlate. Here, indeed, we have not merely a mechanized knowledge, but a mechanized reasoning. If the length and width of a rectangular field are known, we have but to put these numbers into a machine and the computed area is returned to us, and we accept it as certain (certain, at least to the degree of accuracy of our original measurements). In fact, we trust the machines to a degree that we do not credit our own faculties. Clearly the relation between the area of a rectangle and the length of its sides is a fixed one. Once we have discovered it, we need not return each time and go through the stages of observation, tentative definitions, trial and

error, insight, and verification—always uncertain until the last as to whether our forecast will be verified. The relations between outer events are not so fluid and arbitrary as that. Moreover, when we gather our solutions together, solutions founded on an immense variety of area measurements, and when we devote ourselves as specialists to the study of these solutions themselves, we discover that they are not unrelated. The solutions for rectangular areas are related to those for triangular fields, and the triangular are related to many-sided figures, and these in turn to circles. When we have traced beaten paths from one solution to another and have established (painfully and after discarding some of our "insights" as false) a hierarchy of relations, we find that certain solutions are more useful than others; in a sense they are "basic." These basic solutions constantly reappear in other problems; they provide "handles" by which we can grasp the later ones. (Thus, when we see a triangle as a half rectangle, we have a formula for computing its area.)

Now of such basic truths are the axioms of mathematics constructed. They are the congealed (and in a sense mechanised) results of centuries of discovery. They are the products of the reasoning process we have been describing rather than the process itself. They constitute a "closed system" in the sense that they represent for us "closed issues." Who would think of questioning the axioms of Euclid? These are beaten paths; in fact, their hoary character gives them the sanctity of eternal truths and we are inclined to take them, not as a set of recipes found workable by a human intelligence that is frequently untrustworthy, but as the original drawings from which the Creator first made the universe.

But problems may arise for which this logical machinery is unsuited; or the specialist tracing out the implications in the network of old solutions may be led to absurd and self-contradictory conclusions. Then the mathematician specialist will be led to seek new insights, and reorganize his hierarchy of axioms. Algebra, the integral calculus, and the non-Euclidean geometries represent such inventions and discoveries, each one providing a tool of greater flexibility (and greater generalizing power) than its predecessors. Thus, from the manual task of mensuration to the farthest reaches of pure mathematics, we see a "logic" developing out of human operations, human "modes of conceiving." Once developed and codified, it has the coercive power of a useful tool, of the opinion of the most experienced operators, of tradition.

Just as grammar is a codification of speech which grew up in innocence of the formal rules eventually established, so the body of scientific knowledge may be viewed as an ordered presentation of the practices which have grown up in the various fields of human interest. The practices of the market place, industry, medicine, become the logics of economics, engineering, physiology, and the "basic" disciplines, physics, chemistry, and mathematics. And in the political forum will arise those conventions which will become the canons of logic by which we measure the validity and coercive power of the arguments of those who would persuade us to adopt a course of action.

The implications of this view cut in two directions. It informs us that logic and the sciences do not give us some new and transcendent mode of thought, some special avenue to truth and certainty. If they are transcendent in any sense it is in the sense that the tried and tested social achievement is superior to the inexperienced guess of the isolated individual. But it is equally true that once these constructions have arisen they will have a powerful influence on all subsequent thinking. They provide the models, schemata, with which we approach reality, and their "principles" (the accumulated residues left by millions of observers) provide the canons of criticism.

Logician and Reasoner.—Now the logician proper is a specialist who devotes himself to a study of the schemata. Like the literary critic, he is not involved in the actual process of creation, but in the criticism and evaluation of the products. He has developed his own system of conventions, symbols, his classification of fallacies, sophisms, and paradoxes; and in the course of so doing he has discovered errors in the products of human reasoning and has developed a useful machinery of criticism. The logician's equipment bears a relation to the actual process of reasoning similar to that which the physician's concepts bear to the physiological processes of his patients. And when physician and logician are confronted with their problems (medical and logical) their reasoning is facilitated by their tools, but it is not confined to a mechanical type of operation. Even a logician depends upon his hunches, insights, and is helped by the proper "direction," and leaps to his conclusions at one bound, even if he later chooses to give them a formal, logical dress.

Consequently, we should not look upon the logician's rules, and syllogisms, as the prototype of human thinking. We should look to him for warnings as to the location of common pitfalls, for

a method of dissection to apply to our opponents' arguments (whereby we may lay bare their fallacies and so annihilate them), and for a framework upon which to hang the dried specimens we have collected, that we may better view and classify them.

In these latter days there has arisen a logic of logics, a comparative logic. The deductive logic of Aristotle has been corrected by the inductive logic of modern science; both have been subjected to the criticisms of a dynamic logic and theories of symbolism. We are warned, for example, that all our truths are conditional, that none of our terms will "stay put." Whereas Aristotelian logic demands that "*A* is never not-*A*," modern logic reminds us that "*A* may be not-*A*, *A*, or neither."[1] Whereas an older logic demanded universal truths as a starting point, modern logic prefers to regard "no statement with meaning as indisputable."

One of Sidgwick's examples may serve as an illustration:

> Boiled fish is good for fever patients.
> Here is some (stale) boiled fish.
> Therefore . . .

The point of the illustration lies in the fact that the present situation where I need to use my logical machinery is always a situation-with-a-difference. I can never know, just because the old term "boiled fish" fits, that its old connection and consequences are applicable and relevant. With the most complete logic I am still dependent upon "native wit" and "sagacity" in isolating the essence of a situation.

Another way of affirming the difficulty is to assert that the properties of my "terms" which I have hitherto known in isolation may be altered by the very fact of their juxtaposition. Natural events, like people, have a way of violating expectations when viewed for the first time in new surroundings. No logical machinery will fill the gaps created by limited experience.

Logic, like the rest of our thought models, develops and changes by being used. Like any other type of visual material, its symbols will be subject to wishful and illusory distortions, to the difficulties arising from context (embeddedness, distortion of the frame), and like the rest of our concepts, they are the outgrowth of practice, and in turn influence further actions.

[1] Sidgwick, A. *Elementary logic.* London: Cambridge Univ. Press, 1914.

In spite of the fact that the work of any logician is subject to all the pitfalls which beset any human thinking, his product, like that of the scientist, is most useful. Like the findings of the scientist, his canons have been tested and verified. His system is internally consistent. Accept his premises, and his conclusions follow. Neglect his tests, and his principles, and waste time in the fruitless demonstration of false conclusions.

Logic is thus a tool which we must learn to distrust, and to use with caution; but which we dare not neglect if we would seek that practical efficiency and certainty which is humanly possible.

CHAPTER XII

INTELLIGENCE

Intelligence as Native Endowment

We do not hesitate to characterize behavior as intelligent, or stupid; but when we are forced to state precisely just what intelligence consists in, we find our task anything but simple. Since the turn of the century, when the first intelligence tests were being devised, psychologists have attempted to define and analyze this trait, and their formulations range all the way from "a native capacity" to "conformity with the cultural norm."

If we turn to the idiot, imbecile, and feeble-minded, it will appear that we are dealing with some inherent, constitutional defect. Whether it is heritable or not—whether it springs from defective genes or birth injury—it appears as a stubborn type of deficiency; for these defectives respond slowly, if at all, even when the best environmental conditions are provided for them. Rarely, as with the cretin type, specific medication applied early enough may bring about normal or near-normal development. But, in the main, the limited results which can be achieved with even the higher levels of feeble-mindedness, with the best pedagogical and institutional care, make the defect in intelligence appear as a fundamental limitation in the capacity to learn, to profit by experience, to adapt to the environment. If the feeble-minded child can be taught simple routine manual skills and habits of neatness, if he can be "domesticated" so that with a minimum of responsibility (and this implies considerable supervision) he is fitted for some very humble role in society (instead of remaining a menace and a social charge), his teachers feel gratified.

Thus, by the inverse process of considering those who lack intelligence we have come to one definition of the trait: a biological capacity which limits educability.

This inability to learn has made the child of subaverage intelligence a constant problem for the educator, and gave rise to the first attempts to measure the trait. Terman points out that

> . . . from 10 to 15 per cent [of our school children] are retarded two years or more; and . . . from 5 to 8 per cent are retarded at least three years. More than 10 per cent of the $400,000,000 annually expended in the United States for school instruction is devoted to reteaching children what they have already been taught but have failed to learn.[1]

If such a high percentage of deficient scholastic performance is the outcome of defective endowment, then there is need for some type of measure which will yield rapid and accurate diagnosis. To attempt to apply uniform educational procedures where ability differs widely, to attempt to impart what lies beyond the capacity of the pupil, and to postpone the recognition of defective endowment until persistent failure has given the pupil a profound sense of his worthlessness (and has produced either discouragement or behavior disorders), is obviously wasteful both with respect to the individual and with respect to the public funds devoted to instruction.

The Measurement of Intelligence

A Sampling Procedure.—All measures of this "endowment," or "capacity to learn," must be, in the nature of the case, indirect. Like other functions (*e.g.*, speed of movement, irritability), intelligence is manifested by the living organism in action. It resides in no spot, it is not an organ which we can weigh and measure. Moreover, any measure of this functioning organism will reveal more than "native endowment." Is the child (at the time of the examination) rested or fatigued, frightened or at ease, well nourished or emaciated; is the language and manner of the tester like that of the child's parents or playmates; are the materials of the test familiar or strange? The very formulation of such questions shows that we shall be able to make a proper inference about the child's capacity only when our test materials have been most carefully selected, when we have standardized the methods of administering the test, and when we have properly evaluated the influences which have played upon the developing child up to the moment of the test.

The tester utilizes what is essentially a sampling method. Although he cannot get at a pure and unalloyed "capacity to learn," he can at least sample what has been learned. Given an identical or common environment, differences in original ability will yield

[1] Terman, Lewis M. *The measurement of intelligence*, p. 4, Boston: Houghton, 1916. Reprinted by permission of the publisher.

differences in what has been acquired. To provide valid comparisons of endowment, therefore, all test questions must be directed toward functions or skills arising out of such a common environment. Thus, if we represent accomplishment, nature (endowment) and nurture (environment, training) by the symbols A, Na, Nu, then

$$A = Na \times Nu$$

If we can equate the nurture factor for our subjects, our test scores will provide a measure of the nature factor.

The Selection of Test Items.—If we neglect for the moment the problem imposed by our testing logic (the necessity of sampling a *common* environment), what types of questions should we ask the child? Obviously, the questions suitable for a twelve-year-old will be beyond the three-year-old. We need a list of questions of graded difficulty. And precisely what type of questions will measure intelligence? Can we by some sort of a priori analysis determine the functions which make up intelligence, as, for example, memory, reasoning ability, knowledge of common objects, ability to name and count, ability to draw, to compare, to read, etc.? And how shall we weight these items so that a true measure will be obtained?

The psychologist can merely give his best guesses to these questions. The child will determine the correctness of his answers. Are his questions suitably graded in order of difficulty? If so, the age groups will yield progressively higher averages. Giving the test to children of varying ages will reveal the order of difficulty, and the results will enable the investigator to eliminate all questions which do not discriminate between levels of ability.

Are the questions mere "stunts," or do they really measure intelligence? Are they properly weighted? If we recall our original purpose, the detection of those who are incapable of making normal school progress, we shall have a criterion which will automatically answer these questions. The experimenter will eliminate those questions which are not diagnostic, and weight the remainder so that they provide the best measure. If a test that is largely devoted to exploring the child's vocabulary proves to correlate closely with scholastic achievement and provides in addition a clear differentiation between age levels, then it becomes automatically an important component in intelligence.[1]

[1] The use of such a criterion in determining the validity of any test suggests another definition of intelligence; namely, *scholastic aptitude*.

Thus we might outline the steps in the construction of a test, as follows:

1. The tentative assemblage of materials.
2. The empirical selection and arrangement of the items through their actual administration to representative samples of the population.
3. The standardization and validation of the final test—a standard method of administration, a uniform method of scoring and weighting, the establishment of norms through correlating test performances with age levels and some other accepted criterion of intelligence (*e.g.*, scholastic success).

Before the test becomes a satisfactory measuring instrument its *reliability* must be established. Alternate forms may be constructed and standardized, or the same test may be repeated with the same subjects, or scores on one half of the items may be correlated with the other half. If the variability in ratings is too great, then no great weight can be given to any one measurement, and the test itself will appear to be a sort of "rubber yardstick." If, however, the different measures prove to be consistent with themselves (as when self-correlation values are greater than 0.90), the scores become significant measures and are worthy of further interpretation.

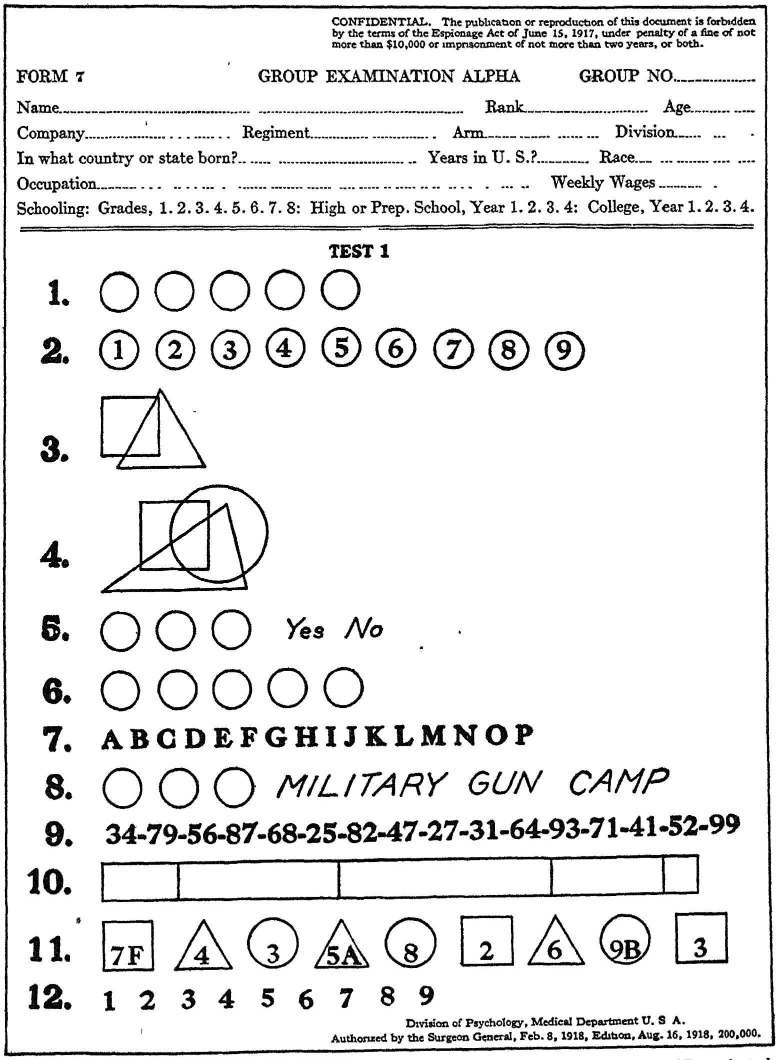
Samples of Test Materials.—A wide variety of test materials has been employed. Some, of nonlanguage variety, have been devised to overcome the obvious handicap of the foreign born. Some of the verbal-linguistic variety require a great deal of time from the examiner, and when large groups are to be tested some sort of "group test" that can be rapidly and easily administered is needed.

The first type of test is illustrated by the form-board type of test, in which wooden blocks have to be fitted into holes in a larger base board within given time limits. Other tests patterned on the jigsaw puzzle can be devised up to any desired level of complexity. A block test (Kohs), in which the subject has to copy a presented design, has also been developed and standardized. Gestures and demonstrations can replace the verbal type of instruction, and if procedures are adequately standardized reliable results can be achieved.

The group test may be illustrated by the "alpha" test, which was administered to recruits at the time of America's entry into the World War. The examiner, facing the group of examinees who were seated with test blanks and pencils, called out:

"Attention! Attention always means pencils up. Look at the circles at one. When I say 'Go,' but not before, make a cross in the second circle and also a figure in the third circle. 'Go!'" [See Fig. 108.]

Then within five seconds the second command followed, and as the test progressed the commands grew increasingly difficult. Thus, for the twelfth item:



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FORM 7 GROUP EXAMINATION ALPHA GROUP NO.........

Name.................... Rank.......... Age......

Company.......... Regiment.......... Arm.......... Division......

In what country or state born?.......... Years in U. S.?.......... Race..........

Occupation.......... Weekly Wages..........

Schooling: Grades, 1. 2. 3. 4. 5. 6. 7. 8: High or Prep. School, Year 1. 2. 3. 4: College, Year 1. 2. 3. 4.

TEST 1

1.

2. 1 2 3 4 5 6 7 8 9

3.

4.

5. Yes No

6.

7. A B C D E F G H I J K L M N O P

8. MILITARY GUN CAMP

9. 34-79-56-87-68-25-82-47-27-31-64-93-71-41-52-99

10.

11. 7F 4 3 5A 8 2 6 9B 3

12. 1 2 3 4 5 6 7 8 9

Division of Psychology, Medical Department U. S A.
Authorized by the Surgeon General, Feb. 8, 1918, Edition, Aug. 16, 1918, 200,000.

FIG. 108.—Reproduction of the first page of the Army Alpha test. (*Reprinted by permission of the U. S. Government Printing Office.*)

"Attention! Look at twelve. If six is more than four, then, when I say 'Go' cross out the five, unless five is more than seven, in which case

draw a line under number six. 'Go!'" [The examiner allows ten seconds.]

A second test measures a knowledge of arithmetic and contains such items as

If it takes 5 men 4 days to dig a 200-foot drain, how many men are needed to dig it in half a day?
or
How many cigars can you buy for $1.00 at the rate of 2 for 5 cents?

A third test is described as a "test of common sense." Thus:

If plants are dying for lack of rain, you should water them, ask for a florist's advice, put a fertilizer around them.
Gold is more suitable than iron for making money because gold is pretty, iron rusts easily, gold is scarcer and more valuable.

Other portions of the alpha test sample the ability to apprehend the relationship of oppositeness and sameness, the ability to rearrange words in pied sentences into the correct order, the ability to discover the systematic relationships governing an arrangement of numbers, the ability to sense relationships (analogies), and some tests appeared to measure information exclusively.

One of the most widely used (and most carefully standardized) of the individual tests is the Stanford-Binet scale. The most recent revision of this test provides alternative forms with standardized norms for each age level from two to fourteen years, and with four additional adult levels.[1] In all there are 129 tests, and these are grouped according to age levels, empirically determined. A widely varied content not only samples a broad range of capacities, but aims as well at maintaining the subject's interest. The tests for the upper levels are largely verbal in character, but at the lower levels there are tests which utilize colored cubes, beads, pictures, diminutive objects, in such a way as to lean somewhat less heavily on the verbal-conceptual processes. The authors justify their weighting of the language and conceptual abilities at the upper levels, arguing that language is "the shorthand of the higher thought processes, and the

[1] In standardizing this test the investigators tested 100 children at each half-year level below six, 200 at each age between six and fourteen, and 100 at each age from fifteen to eighteen. Terman, Lewis M., and Merrill, Maud A. *Measuring intelligence.* Boston: Houghton, 1937.

level at which this shorthand functions is one of the most important determinants of the level of the processes themselves."[1]

The backbone of the test is made up of items which appear in most tests of intelligence: "analogies, opposites, comprehension, vocabulary, similarities and differences, verbal and pictorial completion, absurdities, drawing designs from copy and from memory, memory for meaningful material and for digits," etc. There is not space here to present an adequate sampling of the test materials, nor would mere inspection reveal anything important about their value as measures of intelligence. Similarly, if we were to speculate upon the nature of the "faculties" tested we should not come much nearer to an understanding of the nature of intelligence. Some tests seem to call for vocabulary, others are primarily tests of comprehension, but when all the items are studied there is scarcely an aspect of mental life that is not somehow measured: ingenuity, powers of abstraction, inventiveness, ability to repeat words and digits mechanically, memory, form perception, drawing ability, ethical judgment, etc. In fact, the materials are so varied and complex that an exhaustive description of the functions involved would remind us of every psychological problem we have discussed.

Mental Age and Intelligence Quotient.—Better than a speculative analysis is a study of the test findings themselves. In the first place, the subject's performance will show a *basal mental age*. This is the point in the test below which all test items are passed successfully. Beyond this point there will be a range within which items are missed with increasing frequency until none are passed. Each of the tests passed may be given a month value.[2] Thus a ten-year-old may show a scatter from the seventh to the twelfth year. Clinicians regard with suspicion an unusually low base line with very wide scattering. Such "profiles" sometimes appear in adult schizophrenic patients.[3]

A mental age of 10 means that *in this test* the individual's performance falls at the median score achieved by a representative sampling of ten-year-olds. When this index is considered in conjunction with the chronological age of the subject, an index of

[1] *Ibid.*, p. 5. Reprinted by permission of the publishers.

[2] For example, if there are six tests covering the period from IV-6 to V, each test passed adds one month to the basal mental age score (4 years and 6 months plus 6 months, a total mental age score of 5 years).

[3] Cf. Kanner, Leo. *Child psychiatry*, p. 55. Baltimore: Thomas, 1935.

brightness or dullness is obtained. This is commonly expressed as the intelligence quotient (I.Q.) obtained by dividing the mental age rating by the chronological age. Thus a ten-year-old child

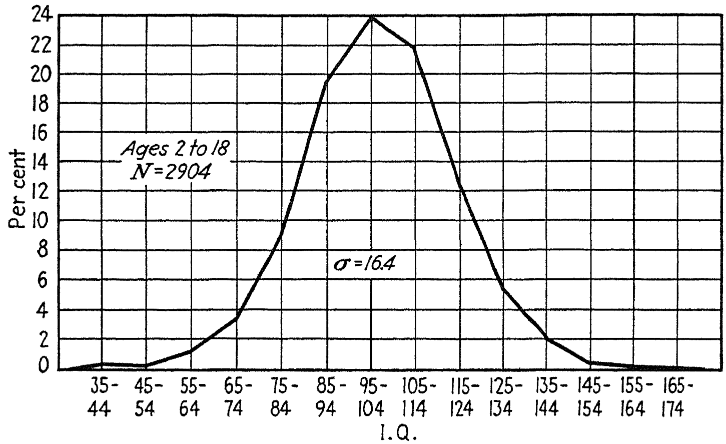

FIG. 109.—Distribution of I. Q.'s of the standardization group in the Terman-Merrill study. (*From L. M. Terman and M. A. Merrill. Measuring intelligence, p. 37. Boston: Houghton, 1937. By permission of the publishers.*)

with an M.A. of 10 has an I.Q. of 100 (the quotient is expressed in percentage terms with decimal omitted), and his intelligence described as average. If he should have an M.A. of 12, the I.Q. of 120 expresses his "brightness." Table 17 indicates the approxi-

TABLE 17—DISTRIBUTION OF THE VARIOUS LEVELS OF INTELLIGENCE IN THE POPULATION[1]

I.Q.	Classification	Per cent
130+	Genius (175) Precocious (150–174) Very superior (130–149)	1
120–129	Superior	5
110–119	Bright	14
90–109	Normal, or average	60
80–89	Dull	14
70–79	Borderline	5
50–69 25–49 0–24	Moron Imbecile (feeble-minded) Idiot	1

[1] Adapted from W. C. Trow (after Terman and Kuhlman) *Educational psychology*, p. 128 Boston: Houghton, 1931.

mate distribution of I.Q.'s in the population, and the descriptive terms commonly applied to the different levels of attainment.

Figure 109 gives a graphical representation of similar facts and is based upon the data obtained by Terman and Merrill in their recent standardization of the Binet test.

These distribution figures are of value in interpreting individual scores. With such figures as background we can better appreciate the degree to which any single measurement deviates from the normal. They do not express the distribution of any biological trait, of "native intelligence" (whatever that might mean); the curve of distribution represents a scattering of advancement and retardation in test performance. And there is nothing whatever mysterious about the "normal" curve of distribution (with its equal numbers of superior and inferior test performances), for the method of standardization makes this form of curve inevitable.

The Growth of Intelligence

The growth of intelligence appears to parallel the general growth curve, with large increments added in the early years, the annual increment decreasing until, when the twenties are reached, test scores show no advance. The difference between the two-year-old and the three-year-old is a marked one, and is apparent to the casual observer; between fourteen and fifteen the increment can be revealed only by careful measurement. While tissues are growing at a near-embryological rate, mental development appears to keep pace, and as the years of maturity are reached and the biological fires are banked we no longer show the steady development of skills and capacities.

Moreover, in this development, the pace which is set in the early years tends to be maintained throughout the period of growth. Bright child, bright adult is the rule. The accounts of eminent men who were dullards as children are largely evidence of the biographer's sense of literary values and do not bear careful examination. Moreover, the bright child, growing mentally at a more rapid rate, does not reach his maximum attainment as soon as the dull child who advances slowly to achieve his limit early.

These are the facts which are generalized in the tester's formula: the I.Q. tends to remain constant. Thus a child who is advanced one year at age 3 will tend to be advanced two years at 6, three at 9, and so on.

Since progress in test performance for the average individual begins to level off at age 13 and has all but ceased by 16, the steady increase in chronological age would give progressively lower I.Q.'s for all adults beyond this age level. To prevent this and to preserve the typical distribution of ability in the adult population, Terman and Merrill begin to introduce corrections for the M.A. at age 13, and beyond 16 the I.Q.'s of all adults are calculated as though the subjects were 15 years of age.

Does intelligence *really* cease developing beyond the age of 16? Does mental ability *really* follow the normal curve of distribution? How intelligent, really, is the average man? If one chooses to confine his answers to actual measurements and if one is prepared to define intelligence as that which the tests measure, these questions can be answered. Thus, we may insist that the average adult has a mental age of 15, that only 6 per cent of the population has superior intelligence, and that growth in intelligence ceases at puberty or shortly after.

When these answers were first given wide circulation by the popularizers of science, many hasty conclusions were drawn. Some thought that it indicated that the average man was of inferior intelligence, or that children knew as much as their parents, etc. But if one remembers that all such generalizations refer to test scores, and if the method of standardization is borne in mind, no such errors need be committed. Because these points are so often forgotten, I am inclined to think that the best definition for intelligence (as a preliminary to a discussion of the psychological literature on testing) is the following: *intelligence is a term which refers to a group of skills measured by the so-called intelligence tests.*

With such a definition in mind, several reasons for the post-adolescent "leveling off" of the curve of mental growth occur. Most obvious, perhaps, is the biological factor. The cessation of growth and maturation would lead one to expect a similar cessation in growth of mental capacities, and to the nativist who looks upon the test as primarily a measure of biological capacities this will seem the most natural explanation. It is also the period at which schooling ceases for the bulk of the population; but the nativist can point to the fact that those who continue through college and graduate school do not achieve progressively higher test scores. He is likely to say, therefore, that after the adult level is reached *knowledge* and special skills may be added, but no new *capacities.*

There is, however, another interpretation of these facts. If we remember that a successful test is one which samples a common environment we can see at once why the increments of the later years are more difficult to measure for the population as a whole; for at adolescence the differentiation process begins. One youth goes into a factory, another into business, others specialize in mathematics, journalism, etc. Each may add to his vocabulary, but the increments will be within highly specialized fields, and only an "encyclopedic" type of test could catch all the increments; and what is true of this test item will be true of other types of test performance. In other words, the failure to show increments beyond the 16-year level (for the average person) may simply indicate that our sampling technique has reached the limit of practical applicability.

It may also express the fact of declining motivation. The world of the child is new and challenging. The demands made upon him continually remind him of the inadequacy of his equipment and he is spurred to new levels. When he has acquired a sufficient number of words for the practical needs of communication, and when he has achieved the skills which are necessary to take care of bread-and-butter needs, he settles into the routine of habits. The test scores thus reflect a relationship between the individual and a surrounding cultural medium, and can never be treated as a simple measure of maturing native capacity, intrinsically determined.

The Interpretation of Test Scores

Now that we have glimpsed a number of the factors which may enter into a test performance, and have some notion of the method of constructing and standardizing such measures, we are in a better position to interpret some of the findings. Probably no single mental measurement has been so widely used as the intelligence test, and it is equally probable that no other psychological instrument is as often misused. In whatever field it is employed—psychiatry, vocational guidance, or social theory—it must be used with caution. It is not a "foolproof" method of diagnosis, and its ease of application is no substitute for wisdom on the part of those who use it.

Sex Differences.—When Thorndike devised an intelligence test for college freshmen, calculated to offer a more efficient substitute

for the conventional entrance examinations, and for the high school grades (which are often difficult to evaluate), two interesting facts emerged: (1) this brief test offered a better measure of an applicant's chance of success in college than any measures previously used; (2) the intelligence of men appeared to be distinctly superior to that of women. The latter fact was also verified by the use of the army mental test. Table 18 shows the scores of men and women when these tests were applied to the entering freshmen in a representative midwestern coeducational school.

TABLE 18.—INTELLIGENCE TEST SCORES OF FRESHMEN MEN AND WOMEN

	Thorndike Test Forms			Alpha Alpha
	Form A	Form F	Form G	
Men..	160	124	126	141 7
Women	118	108	106	110 4

Are we to conclude that the intelligence of men is superior to that of women? (Obviously, yes, if intelligence is what the tests measure.) The meaning of the masculine superiority becomes clearer, however, when we examine some of the test items. For example, in Form F, test 7, of the Thorndike test, these questions appear:

1. What tool do you use to trim down a piece of large timber on a bridge?
2. What is the basis of all light colored paints?
3. What does E.M.F. mean?
4. What do you call the iron pipe through which electric wires are run?
5. What are magneto circuit breaker contacts made of?
6. Why is tin added to a brass mixture?
7. What would you do to reverse the direction of rotation of a three-phase induction motor?
8. What is the purpose of a chuck?
9. With what sort of current is a transformer used?
10. What would you use to draw a line on a large piece of hot metal?[1]

Perhaps the intelligent male in an industrial civilization may be expected to know something of physics and engineering practice. But the questions are so far out of line with what is, at present,

[1] From Form F, test 7, of the Thorndike test. Reprinted by permission of the publisher.

demanded of women, and so foreign to the average woman's experience, that it is not at all surprising that their performance falls below that of men. Another test, equally weighted in favor of feminine skills, would, of course, reveal masculine inferiority.

It appears, therefore, that where there are differences in culture and social background (and therefore in the experiences which are to be sampled) the differences in test scores can not be used as measures of differences in some biological endowment. As for the intelligence of the two sexes, it would seem the sounder thing to assume equal *capacities* and to look upon differences in rating as measures of divergence rather than of levels. As for some original capacity in pure and unalloyed form, we do not measure any such entity. We can only measure the degree to which an individual approximates some specific cultural norm.

If these arguments seem valid, then we shall be prepared to reject some of the interpretations of the test findings which gained currency in the early days of their use. When it was found that recent immigrant groups achieved lower test scores than those who had been here longer it was at first suggested that this proved that the recent "samples" of European population were of inferior quality; and there were proposals to alter immigration policy as a corrective. But it was soon pointed out that, if residence in this country brings about a closer approximation to the cultural norm, similar results would appear even though the quality of the samples remained the same. Intelligence tests have been utilized by those who wish to prove the superiority of the Nordic, of the white as against the black man, of the white as against the Indian; but these ventures have more of a "religious" or "tribal" significance than scientific value. Any race or nationality could construct tests which, if applied to other groups, would yield results flattering to the testers. On the other hand, it may be possible by such tests to measure significant cultural differences. This is a vastly different matter (and more important) and does not involve us in the scientifically impossible task of assigning a rating to a race or culture on some absolute scale of values.

Rural and Urban Differences.—And so it is with comparisons of social groups within a nation. Binet test scores show that rural children fall below the urban, children of the unskilled and semi-skilled laborers fall below the children of the professional and managerial groups, children of the poor (and of the slums) fall below

those of the well to do. But statistical tables demonstrating these facts do not automatically yield an interpretation.

Does the rural child make a poorer showing because he lives in an environment that is less stimulating? Does he, in fact, develop more slowly? Or is the native ability of the country really poorer, the able and active ones having been drawn to the cities? Or is the test really weighted (by the nature of its sampling) in favor of the city child? Would questions about cattle, harnessing horses, growing crops, reveal that—though specialized—the development of the country lad follows a rate curve similar to that of the city boy? When, for example, Hirsch[1] reports that the average intelligence quotient of a group of children of eastern Kentucky mountaineers (904 cases) was 72.5, shall we rigidly apply our urban criteria and classify somewhere between 40 and 50 per cent of these children as feeble-minded? Hirsch comes very close to this conclusion and is willing to attribute but 25 per cent of the test performance to environmental factors. Where children of some localities test higher, he is inclined to attribute this mainly to the "result of blood seeking environment." He writes: "The most intelligent, energetic and ambitious parents either live in or near one of the six favored school or social communities, or send their children to one of them."

Anyone who has lived among these mountainfolk, or who has worked with their children, can suggest alternate interpretations. If our logic is correct, Hirsch's conclusions reveal the bias of the investigator, but can have in the nature of the case no scientific validity.

Class and Occupational Differences.—Class and occupational differences in intelligence are of similar character. Shall we say that the child born on Park Avenue and the child of the slums have a common environment since both reside within a half-mile radius in New York City? Are their "cultures" the same? Or, if the environmental differences are granted (and they extend from the prenatal period throughout life), shall we insist that we are still dealing with a case where ability seeks its own level and that—in the long run—capacity is rewarded according to its deserts? This latter interpretation is offered, for example, by Dr. Goddard,[2]

[1] Hirsch, N. D. M. An experimental study of the east Kentucky mountaineers. *Genet. Psychol. Monogr.*, 1928, 3, No. 3, 189–244.

[2] Goddard, H. H. *Human efficiency and levels of intelligence*, pp. 102 *ff.* Princeton Univ. Press, 1920.

one of the pioneers in the testing movement in this country. He suggests that, while our present system of distribution of wealth undoubtedly has many abuses, it is fundamentally in accord with both the capacity and the desires of those who make up the different strata. The most serious error of all, he feels, is committed by the muddleheaded humanitarian—with vague socialistic leanings—who squanders wealth in distributing social services and financial aid to those who do not truly appreciate it. These efforts are wasteful, he feels,

> . . . because the people who receive it have not sufficient intelligence to appreciate it and to use it wisely. Moreover, it is a positive fact that many of these people are better contented in their present surroundings than in any that the philanthropists can provide for them. They are like Huckleberry Finn who was most uphappy when dressed up and living in a comfortable room at Aunt Polly's and having good food and everything that Aunt Polly thought ought to make him happy. He stood it for a few days and then he ran away and went back in his hogshead with his old rags on, and getting his food wherever he could pick it up.
>
> Aunt Polly's efforts were wasted because she did not appreciate the mental level of Huckleberry Finn.[1]

It requires both a naïve and an uncritical faith in the power of the intelligence test to measure fundamental biological capacity, and a somewhat complacent view of society to accept such an interpretation. The social philosophy which it represents is essentially that of a privileged class; it is a class viewpoint that may serve in the manufacturing of slogans (it has a distinct "bludgeon value") but it can claim no scientific sanction.

Unquestionably there are biological differences between the classes, and in our society there will be a tendency for the physically and mentally unfit to gravitate toward the base of the social pyramid; but it is equally true that the environment provided for the slum child will do much to hamper the development of whatever capacity he has. A class society (which is also a caste society) tends to depress the ability of the masses and to exaggerate the relative competence of the classes. Only one with a strong class bias could find, in the correlation between intelligence and social status, support for the conclusion that ours is the most efficient of all possible schemes of distribution. If much philanthropy fails, as Goddard asserts, it is because it fails to attack the roots of evil; and it has never been

[1] *Ibid.* Reprinted by permission of the publishers.

demonstrated that the evils of our society are rooted in a biologically determined low I.Q. The I.Q. is a symptom, and as such it invites diagnosis; it is not, in itself, a diagnosis. Is the child of low I.Q. undernourished, of foreign-born (and hence of foreign-language and foreign-culture) parentage; is there a generally defective family background; is he from the rural districts, or from an underprivileged group? There are many such questions which must be answered before we shall be ready to interpret the score.

The Application of the Tests

When one realizes the host of factors which may enter into an I.Q. rating one wonders that it has found such wide usefulness. Our logic has led us to look upon the score as a "symptom," or as a sample performance, itself in need of explanation. While the sample shows the processes of perception, memory, reasoning, insight, etc., in operation, we recognize that the test items do not call for native (intrinsically determined) responses, and when *individuals* are compared we may be comparing backgrounds, experiences, cultures. Birth injuries, adenoids, poor nutrition, slum environment, parents who speak a foreign language, the culture of east Kentucky hill country (Indian reservation, or orphanage)—in fact, each and every influence which has played upon the child—may lie back of the score. If all these externals affect test scores, how can we venture to predict future performance on their basis? How can we tell what this particular child's I.Q. will be three years from now? How shall we dare to use the tests for purposes of classifying pupils, giving vocational advice, planning a course of therapy or reeducation?

The fact remains that I.Q.'s are remarkably constant. Half of our cases will not vary more than 5 points when they are retested years later. It is true that one in every hundred will vary by 20 points or more, and one in five will vary by 11 points. But while there will be a margin of error in any prediction based upon a single measurement, and while a few cases will definitely violate expectations, the grosser classifications (defective, superior, average) appear to be ironclad for the bulk of the cases. The changes which are observed, as children are retested during their progress through the school system, have proved to be both minor and haphazard (rather than unidirectional). In view of the known role of the environmental factors, three possible explanations may be suggested: (1)

the environment of the average school child is a fairly constant factor; (2) the period of plasticity during which external changes can alter the I.Q. is over by the time the child has entered the school system; (3) the environmental factor is, at best, a minor one.

Will drastic changes in a child's environment alter test scores? Studying siblings who had been placed in separate foster homes for adoption, Freeman[1] found that: (1) children raised in better homes tended to have slightly higher I.Q.'s; (2) siblings thus separated resemble one another less than those reared together, as is normally the case; (3) the influence of the foster home was greater when placement occurred before six years of age.[2] A further demonstration of the role of the foster home is given when the resemblance between siblings placed in similar homes was found to be greater than in the case of those placed in widely differing homes.[3]

Even such a factor as placement in a nursery school group may affect the I.Q. Dr. Helen T. Woolley[4] reports that of 43 children tested on entry to the Merrill-Palmer School, 63 per cent showed increases in I.Q. when tested from 7 to 14 months later. The average gain was 19.7 points. An equivalent group from similar homes who remained on the school's waiting list and who did not, therefore, receive this "training," were tested at similar intervals. While 33 per cent gained, 36 per cent showed a decrease, and the balance remained unchanged.

Returning to our question, we may say that the I.Q. forms an adequate basis of prediction and may be looked upon as practically unchangeable

1. If our subject has passed beyond those early plastic years before six.
2. If no drastic change in environment is contemplated. (Minor changes produce some change in the early years. Major changes in later years produce negligible effects.)
3. If we deal with a gross deviation which arises within what appears to be a normal environment

[1] Freeman, F. N., Holzinger, K. J., and Mitchell, B. C. The influence of environment on the intelligence, school achievement, and conduct of foster children. *Yearb. nat. Soc. Stud. Educ.*, 1928, 27, 103–217.

[2] Beyond the age of six the change in environment incident to adoption was found to be negligible.

[3] The correlation figures given by the investigators are 0.39 ± 0.07 (for similar homes) as against 0.28 ± 0.08 (for different homes).

[4] Woolley, H. T. The validity of standards of mental measurement in young childhood. *Sch. & Soc.*, 1925, 21, 479.

When all the qualifying facts have been considered, the fact remains that the I.Q. is still our best prediction of school progress. Memory for digits, vocabulary, ability to read, ability to organize verbal material and to comprehend and execute directions—abilities measured by the tests—are also demanded by the classroom. The tests are also significant in vocational guidance wherever the occupations considered involve any amount of verbal-symbolic skill. Low (or even average) scores on the intelligence test mean that such professions as medicine, law, and engineering are practically excluded.[1] Next in order fall the routine clerical and skilled labor groups.

During the war the tests proved useful in selecting those who could do pencil and paper work, read and understand printed orders, and those who were fit candidates for officer's training; but they could not select those who were fit to command. Such factors as military training, aggressiveness, persistence, and courage were not revealed at all; and in this instance these other factors were important in selecting an officer. The test, in short, is a better measure of intellect than of personality, and the personnel office will always be interested in the *man*—even when the I.Q. is all that it should be.

The possibility of a great gap between the intellectual and what we might call the personal capacities of an individual carries with it a note of warning. While we are classifying our grade school pupils on the basis of their I.Q.'s and allowing the brighter ones to progress as rapidly as their ability allows, we should take note of the kind of persons we are building at the same time. The bright youngster who finds himself classified with older pupils may easily be unable to compete with them socially, on the ball diamond, or in playground tussles. Unable to participate as an equal, and possibly disliked as a too-precocious pupil, he may become unduly timid, asocial, introverted. He may feel that he is "not like the other boys," that he is less manly, etc. The dull pupil is by no means the sole problem of the school psychologist. Dr. Marion Kenworthy describes instances of school failures of youngsters whose I.Q.'s (150 or better) place them in the near-genius category.[2] Sometimes the failure originates in the overanxious parents, who have held up

[1] Although those with I.Q.'s of 100 may complete high school, they are generally regarded as poor college risks.

[2] Kenworthy, M. E. Some emotional problems seen in the superior child, in *The Child, The Clinic, and The Court.* New York: New Republic, 1925.

an impossible ideal of accomplishment. In other cases it arises from the unwholesome social situation of the school. Dr. Kanner reports that "of 1,000 children not less than eighty-four with quotients above 110 presented behavior problems."[1]

For such reasons as these, the competent tester will look beyond the score that is achieved. The child may be anxious, suspicious, unresponsive, smart-alecky, playful, unduly dependent upon his mother, etc., and such traits may be as important as his I.Q. in diagnosing his behavior difficulties. In fact, they may enter into the testing situation itself so that they affect the very measurement of intelligence. As Terman and Merrill comment, " . . . no degree of mechanical perfection of the tests themselves can ever take the place of good judgment and psychological insight of the examiner."

Feeble-mindedness, Delinquency, and Crime

There are many reasons why one should expect defective mentality to be associated with crime. For one thing, life will press most heavily upon those "stragglers" in the struggle for existence whose mentality has not equipped them for successful competition. And, if they are unable to win a place in an environment that is too complex for them, they may be driven by pressing necessity to seek solutions of a simpler, more direct, but possibly antisocial character. If it is difficult for the best of us to live within our budget, how shall we expect the moron to fare when he is subjected to high-pressure advertising and selling methods, when he is offered easy time payments, etc.? How can we expect him to foresee the complicated consequences of his acts when he is equipped with the mentality of a ten-year-old (or less)?

Moreover, the incidence of feeble-mindedness is greater in precisely those quarters of our cities where crime and vice abound. How shall we expect the feeble-minded child's limited powers of discrimination to sift the "good" from the "bad" in the social patterns presented to him as copy, when the "bad" happens to be the mode in his particular neighborhood? His incapacity to compete success-

[1] Dr. Kanner classifies the difficulties associated with a high I.Q. as springing from (1) undue emphasis on the child's accomplishments, making the child the center of attention and cultivating an insatiable appetite for praise, (2) not providing him with enough to do—thus giving opportunity for mischievousness, daydreaming, etc., (3) allowing him to develop one-sided, bookish interests, and permitting a mushroom growth of the intellect while the normal social needs are neglected. Kanner, Leo. *op. cit.* Baltimore: Thomas, 1935.

fully for a livelihood forces him to live under the very influences he should be protected from.

Thus, without positing any criminal tendency as a natural accompaniment of feeble-mindedness, one would be prepared to understand why the defective mentality under modern social conditions would learn criminal ways.

Such a view of the criminal marks an advance beyond the "eye for an eye" philosophy which never asked for causes, but sought only to deal out "just" punishment. And it is more hopeful than the view which saw crime as the inevitable outcropping of a "criminal instinct." But the hope which it offers to society as it is now constituted is still distinctly limited. Those who look upon feeble-mindedness as mainly a problem in "breeding" sometimes offer eugenics as a program; but there are few reputable biologists who look upon the program with enthusiasm. Feeble-mindedness is not the result of the operation of a simple unit character, and the type of control over mating which would be involved in a thoroughgoing eugenics program is not yet socially practicable. Those who look upon the problem as one of supervision, guidance, and protection of those of low intelligence are forced to envisage an economic problem that is staggering.[1] Those who propose to eradicate the environments which foster antisocial behavior may as well plan to revamp the social system.

Before we direct our efforts to one line of attack it would be well to press beyond our speculations to the criminal himself. However plausible the logic and however cogent the voice of authority, it is possible that our speculative structure is without benefit of factual foundation. Dr. Goddard once asserted that "the greatest single cause of delinquency and crime is low-grade mentality, much of it within the limits of feeble-mindedness"; and he estimated that an examination of the inmates of prisons would show that from 50 to 80 per cent of them are mentally defective. Such estimates were common before the army mental tests showed that the actual level of performance in the adult population outside of prisons was not so high as had been anticipated. As more satisfactory norms were achieved, the studies of the prison population revealed that the gap between the delinquents and criminals, on the one hand, and

[1] This would mean an institutional life for over one million persons in the United States alone, if only the more extreme types of defect are to be institutionalized.

the socially adjusted, on the other, was a very slight one. In fact, when one remembers that the less intelligent are more likely to be caught, the relation between intelligence and antisocial tendencies becomes a dubious one. Further grounds for skepticism are supplied by a study which shows that a similar selective process operates upon those who are caught: the defectives are less likely to be paroled, or given suspended sentences, or to be released as not guilty.[1]

We should remember, too, that there are different types of crime, and antisocial conduct exists in all social strata. The I.Q. of the industrialist who defrauds the government of several million dollars in income tax is in all probability average, or above. The girl of good family who "gets in trouble" seldom has to undergo mental examination by the psychologist in the Bureau of Juvenile Delinquency, for her family comes to her rescue and the thing is hushed up. But the poor and the friendless mental defectives, convicted of minor thefts, and the "lower class" girl, who drifts into prostitution, will contribute their test scores to our studies of the intelligence of the institutional criminal.

Finally, we would do well to remember that there is nothing intrinsically peculiar in the criminal act itself; that crime must be defined in terms of social relationships. For every bootlegger, prostitute, dope peddler, whose activities involve the constant threat of arrest, fine, and imprisonment, there will be an extensive clientele of "good citizens" who patronize him. Organized crime panders to the "needs" of those whom we seldom brand as criminals. And the changing laws and customs of a people have a way of legalizing tomorrow the activity that is criminal today.

Thus, while the intelligence test may prove valuable to the prison administrator, in classifying his prisoners or in assigning them to tasks, or to the parole officer, in estimating the probable behavior of his charge, they are in no sense a diagnosis of the causes of antisocial behavior.

[1] Ploscowe, M. Some causative factors in criminality, in *Report on the Causes of Crime*, Vol. 1. National Commission on Law Observance and Enforcement, George Wickersham, Chairman. Washington: U. S. Govt. Printing Office, 1931.

CHAPTER XIII

PERSONALITY

Introduction

A Synthetic View of the Individual.—In turning to the problem of personality we complete the cycle of our psychological studies. Again we shall do well to remind ourselves of the pitfall that has trapped so many thinkers. From the time of the ancients who sought to discover the locus and nature of the anima—that spiritual essence which made the material body go and was somehow separable from it—down to the present there has always been the tendency to reify the process studied and to invent mental or spiritual forces which somehow lie behind the activities. We found that the anima of the Greeks had its spiritual descendant in those "instinctive" forces which more recent writers refer to. Likewise we noted a tendency to think of "will power," reason, intelligence, as properties or forces existing apart from the concrete acts which are observable. We face the same problem in dealing with personality.

When we have measured the intelligence of an individual, studied his interests and strivings, noted the situations which provoke emotional responses and described his method of expressing these same emotions, observed the ways in which he meets his problems (and frustrations), and in particular when we have studied his reactions to other people (his family, the larger social group with its standards and demands), we do not then go on to look for a "plus something," a personality which lies behind the phenomena we have studied and which somehow pervades, unifies, and directs the whole. Our study of this totality of the behavior of the individual *is* the study of personality.

Such a study differs from our previous analyses of motivation, emotion, memory, reasoning, intelligence, perception, etc., in that we are trying here to make a synthesis of the many aspects which we have treated singly, and in the fact that we are not considering a process as it appears in many individuals but rather a particular constellation of traits, assets, and liabilities within a particular

situation and life history. In one respect these aggregates of traits (which we call persons) are absolutely unique. No person will show precisely the same constellation as another; two life histories (even of identical twins) will never be identical.

Are There Basic Traits?—There is little point to any attempt to define personality beyond this. We cannot set up a definition that will demonstrate its very essence, and then deduce from our definition a set of conclusions as to what a study of personality *ought* to cover. There are no "basic" personality traits, save as the traits are of significance to the purpose of some particular investigator. Psychiatrist, salesman, educator, and sociologist may find many points of interest in common; but as surely as their interests are not identical they will not assign equal weight to the different aspects of behavior and each will find significance in some traits which the others will discount or find of no value whatsoever. One classification that found use in France during the World War divided the men studied into abdominal, respiratory, muscular, and nervous types, in the endeavor to select candidates for particular branches of military service. The muscular, for example, were not so phlegmatic as the abdominal and not so excitable as the respiratory, and they were, therefore, adapted for those tasks which called for stamina and patient persistence. The nervous type, so called, was composed of the intellectuals, the versatile and adaptable who could quickly summon their reserve powers in emergencies. But while this type of classification suited military purposes, there is nothing about the grouping of traits to mark them as fundamental. Certainly an educator would think of other lines of division as of more importance for his purposes. And as for making a *complete* description of a person that will satisfy each and every purpose, we may as well eschew that objective along with the philosopher's quest for the *thing-in-itself*.

Relativity in Personality Estimates.—We may also note another point at which relativity enters into our description of an individual. Like the physicist's problem in the measurement of motion, every estimate of an individual is made from some basis of reference—whether the latter is conscious and explicit, or not. To consider the broadest aspect first, the cultural framework within which we live, with its folkways and its system of values, provides us with standards against which the individual is measured. Each culture will have its "sensitive" spots—standards from which deviation

is not tolerated—and it will also have its blind spots. Thus, the list of important and basic traits which a hypothetical Polynesian psychologist would draw up would scarcely conform to the one that would appeal to us as members of the particular brand of Western civilization now extant.

And what is true on this larger scale tends to repeat itself when we consider the performance of individual raters. Whether we examine a group of biographies of eminent men or sit in staff conference with a group of psychiatrists conferring about a patient, we cannot escape the conclusion that the personal bias and interest of the person who makes the description (and individuals have sensitive areas and blind spots as do cultures) alters the product. It would appear, therefore, that when the human individual himself serves as the measuring instrument, it is as important to know who is doing the estimating as it is to know the estimate. Landis illustrated[1] this fact rather neatly when he was able to show that tall people tend to overestimate the height of others, fat people to overestimate their weights. Unless the standards we carry with us are made explicit, and unless we know something of the frame of reference within which the judgment of a person is made, we shall be unable to interpret the facts which go to make up the psychology of personality.

The Problem of Measurement.—Realizing the subjectivity and relativity of our everyday estimates of personality, psychologists have sought, particularly during the past two decades, for more reliable and objective methods of measurement. They have been prompted, too, by the time-consuming character of any accurate and exhaustive study of the individual. Even the bare outline of personal history which often has to suffice in the case of the busy clinician requires more time than he can easily find at his disposal. In addition to these aims (objectivity and speedy diagnosis), the psychologist has been spurred by the conspicuous success of the intelligence tests. If this aspect of the individual's behavior can be measured in the course of a brief test—and in such a way as to yield results which can be verified by other testers at a later time and which will correlate well with commonly accepted criteria (such as school success)—why can we not use a similar approach to such aspects of the individual's behavior as honesty, seclusive-

[1] Cf. Landis, Carney. Questionnaires and the study of personality. *J. nerv. ment. Dis.*, 1936, 83, 125–134.

ness, emotionality, tendency to anxious or depressive moods, inability to make decisions, capacity for leadership, and so on?

The problem of measurement consists, then, in devising tests which can be administered within a reasonably short period of time. The test items must yield facts of such a nature that other observers (with whatever standards and biases) can verify them. In other words, if we are to characterize an individual as seclusive we must show wherein this behavior is manifested, and in such an unmistakable fashion that the facts cannot be missed by any observer. Finally, we shall need criteria against which to check the test findings. To say that we have devised a test of introversion, and that our subject (or patient) has achieved a certain score on the test, is one thing: but to prove that our measure of introversion is of any value, or that it correlates with any other commonly accepted sign of introversion, is another (as we shall see later).

This problem of the validation of the test is perhaps the most difficult of all. One cannot even say that those who have lived longest with a person are the best judges, for apart from the fact that their own personalities are involved—and their low degree of insight into their own personality make-up would be correlated with their inability to judge correctly those around them—those nearest at hand may be very poor observers, they may not know what to look for, their vocabulary for expressing what they dimly feel may be wholly inadequate, or they may simply lack the intelligence necessary for discriminations in this field. The psychiatrist and social worker who seek information from relatives often come away from an interview feeling that the real behavior problem lies in the individual's surroundings; and they are often forced to appeal to outsiders before they can discover the facts they seek. In many cases the clinician is thrown back very much upon his own hunches, upon his skill in the direct sensing of personality traits which has been developed (he can scarcely tell how) through long experience in dealing with clients.

We are thus left with the "experienced judge" as our final criterion. our last court of appeal. Particularly is this true in view of the present experimental stage of personality testing. With the majority of our tests showing low reliability (with retests yielding variable scores) and uncertain validity, we can scarcely dispense with the more cumbersome and time-consuming method of the clinician. Although he cannot wholly escape the pitfall of subjectivity, his

years of experience and his extended study of the individual afford the best available standard of comparison.

The Clinical Approach

Procedure.—What does the clinician look for, and how does he proceed? Here no single set of answers will cover the wide range of clinical performance; but if we take as our representative clinician a man of eclectic tendencies, not too much dominated by any one school of psychological thought, and in addition reluctant to inject interpretations before he has accumulated his facts, we may come reasonably close to an answer.

One word as to general procedure. By direct questioning of the subject he tries to draw out his facts. Naturally, he will have to adjust his vocabulary to his subject, and his questions will ideally deal with specific and factual material, and not with such general questions as "Do you consider yourself to be an emotional (or seclusive, or obstinate, etc.) person?" He will endeavor to check his findings with the observations of others (teachers, friends, relatives, employers), but he will have little to guide him in evaluating discrepancies save his own sagacity. Throughout the examination he will watch the gestures and incidental expressive movements of his subject. A flush, an embarrassed cough, silences, and evasions will all be as important to him as the direct statements of the subject. His relation to the person examined will be as informal as is consistent with the maintenance of mutual respect, and he will avoid passing judgment on his subject, maintaining the attitude of a sympathetic listener interested in helping the subject to a fuller understanding of his own problems. Upon this latter attitude depends much of the clinician's success. One might even say that only where this attitude prevails is there any possibility of (or even a right to make) a thorough and revealing personality study. When the subject participates in such an interview for the purpose of obtaining help, and when he understands that the facts obtained never pass beyond the interviewer, he will frequently give answers which are unobtainable by any other method and will show a degree of insight into his own problems which another investigator may be wholly unable to discover.

A Typical Clinical Analysis.—Let us consider some of the items which the clinician will want to explore.

Intellectual Traits.—In the absence of an intelligence test the clinician may attempt to evaluate his subject's intellectual traits in terms of such factors as the following:[1]

Schooling. Ease of learning, advanced or retarded, schooling commensurate with opportunity or not, position in classes, special subjects in which skill was shown, ability to concentrate, etc.

Nature and type of interests. Preferences for manual or mental activities, special skills (artistic, mechanical, etc.). Tendency toward personal interests as contrasted with interests in objects, things.

Quality of mental operations. Haziness or clearness in thinking. Poverty or wealth of ideas. Alert and interested in outer events as contrasted with tendency to daydream. Concrete or abstract. Rapid or slow. Analytic or intuitive. Creative, inventive, as contrasted with routine or banal. Persistent and unflagging, or distractible and easily fatigued.

Practical performance. Good or bad manager. Good common sense or poor judgment. Capable in positions to which entrusted. Ability to plan, and type of plan, for career in the future. Foresight and definiteness in planning, as contrasted with vagueness and impulsiveness.

It will be seen from an examination of these items that the clinician aims at a qualitative appraisal of his subject rather than any index number or quantitative statement as to the amount of intellectual capacity. And it will be apparent that some of his judgments will be difficult to verify, that his terms admit of wide latitude in interpretation, and that his "measurements" are in many cases made against a subjective standard.

Even where the I.Q. is obtained by routine testing procedure, as is now commonly the case, the clinician cannot escape an evaluative task. The test score itself will be affected by other "personality" factors: the subject may be attentive or easily distracted, responsive or stubborn and uncooperative, alert and persistent or easily discouraged and fatigued, shy and embarrassed or inclined to "show off," flippant or serious, frank or suspicious, etc. These factors are of importance to the clinician, not merely because they affect the intelligence score, but because they reveal other and equally significant aspects of the personality. In fact, one comes to suspect that the test is not a measure of any such abstraction as "pure

[1] Most of these items appear in such outlines for personality study as the one presented by Dr. George Kirby's *Guides for history taking and clinical examination of psychiatric cases* (Utica, N. Y.: State Hospitals Press, 1921) or in Chap. 1, pp. 9 *ff.* of Dr. Oskar Diethelm's *Treatment in Psychiatry* (New York: Macmillan, 1936).

intelligence." Among other things, the subject is asked questions which call for ethical knowledge and aesthetic judgment (even though minimal). We measure his ability to repeat by rote, to adapt to novel situations, to handle abstract and mathematical concepts, to organize, understand, and define words. And in such a congeries of functions it is important to know wherein the subject fails, the high and low points of his performance, the amount of scatter. And we shall need to evaluate all these in the light of his surroundings, his educational opportunities. We shall not expect the same performance from the mountaineer's children or from the children of foreign-born parents as from the native-born, urban child of average schooling for whom the tests are standardized.

From these observations it will be seen that personality traits are not easily isolated, and that the clinician has learned to consider *traits-in-relation* rather than as so many separate and independent entities. Thus, he may see the child with superior intelligence getting into difficulty because of poor discipline, or because of not having enough to do, or because his home has overemphasized his bookish accomplishments to the extent that he has become a day-dreamer, indulging in fantastic flights of fancy and totally failing in his social adjustment. The dull child who grows up with ambitions commensurate to his capacities may present no problem whatever; but when his limited capacities are coupled with high-flown ambitions and his parents accentuate the problem by accusing him of laziness when he fails at what they consider the only worth-while tasks, his sense of inferiority, his anxious, strained (and frustrated) approach to life may lie at the root of neuroticism or delinquency. Even the child of normal or superior intelligence will show the same traits when he has skipped too many grades, and when his environment has produced the same strained relation between his ambitions and his accomplishments.

Emotional and Volitional Traits: Energy Output.—The second dimension of the personality which is of interest to the clinician deals with the individual's general method of reacting, with the form and style of his responses, the amount and direction of his energy.

Output of energy. Is he active, energetic, hard-working; or is he indolent, passive, deliberate, sluggish? At one extreme he may show too much push or tension, giving the impression of an almost frantic overactivity. At the other extreme his lack of energy and the ease with which he is fatigued may suggest

some failure in those physiological processes which supply the needed combustible chemicals.

In this connection the clinician notes the breadth of his interests and their character. Are they many or few in number, and do they tend toward the overt, manual, athletic, or to the more quiet, bookish, or sedentary type?

Mood and temperament. Individuals vary in their basic mood—which is more or less persistent—and the clinician endeavors to discriminate between the calm and even-tempered, the gay, optimistic, and cheerful, and the gloomy, pessimistic, anxious, or irritable. Some are easily aroused to emotional reactions and freely expressive, others are more phlegmatic or inhibited. It is important to distinguish between ease of arousal and ease of expression of the emotions; and it is important to distinguish between the more or less continuous mood, and those expressions which are "reactive"—that is, which are determined by specific and transient situations. Likewise it is important to separate what we might call "legitimate" expressions (which are directed usefully toward causative situations) and those which are directed toward the "audience," or those which seem bizarre and poorly related to either mood or situation ("ups and downs" in mood without apparent cause). Even the type of humor (as well as its absence) will be of significance, for attitudes of kindliness, hostility, and inferiority (as well as other types of conflict and repression) will be portrayed in the nature of laughter-provoking situations.

Volitional traits. Are his interests of short duration, or is he persistent in the pursuit of a goal? How does he react to interference, thwarting? (By giving up easily, by passive compliance—with hidden resistance, by temper outbursts, by an active struggle, by stubborn opposition?) Is he prompt in achieving decisions, or is he slow, vacillating? (Between the impulsive who rush in without due consideration and the overcautious who seem unable to achieve a resolution of their conflicting plans of action there are many gradations to be discriminated.) The inability to select and discard (successfully repress?) may hamper efficient action; and the inability to suspend action until eventualities are examined and planned for may make action unnecessarily wasteful and heedless.

There are two important ways in which we may classify personalities with respect to their general volitional make-up: (1) their creativity, the ease with which their energy flows into productive channels (what we might term the "positive thrust" of the personality), and (2) the degree to which activities are organized, integrated, cumulative. With respect to the former criterion, one distinguishes those rather passive individuals who seem to need some external impulsion before they can be got under motion, who live somewhat parasitically upon the energies of stronger personalities about them, who need to be "attached" to some going enterprise if they are to function at all, who function best under discipline (whether of business organization, monastery, military post, or domestic establishment), from those who operate freely "under their

own power." The former are more comfortable when others assume the responsibility for their acts; and when there is no one to drive them they may either lapse into a vegetative type of inaction or merely fret under a gnawing sense of guilt.

With respect to the second criterion, one distinguishes those whose lives consist in a series of monkeylike impulsive actions, unpredictable, changeable, with shallow interests of brief duration, from those whose lives are well organized and who are able to construct and follow consistently long-term plans. In some instances disorganization will seem to be a phase or a result of mental illness or unusual stresses, while in others it seems to be a case of poor organization in the first place for, whether through environmental factors, faulty discipline, broken homes, too frequent changes of the family residence, or—as some assert—through some more fundamental constitutional defect, they have never been able to achieve anything approaching an integrated personality.

Attitudes toward the Social Group, toward Other Persons, and toward One's Self.—This third dimension of the personality, like the other two, is not something which exists in an isolated compartment. In considering emotional and volitional reactions we have had to include reactions to other persons, and we have already shown to what a degree intelligence is socially conditioned. Nevertheless, it is worth our while to give special attention to this aspect of the personality, for all those traits which are specifically human bear the imprint of social forces.

Reactions toward other persons. Is the individual at ease with others (particularly with strangers), sociable, easy to get acquainted with, able to make conversation, able to adapt himself to social situations, or is he shy, seclusive, with few friends and acquaintances, most comfortable when alone or within the confines of a rather narrowly restricted social environment? Are his "nest habits" so strong that he finds it difficult to travel, to change his place of work, to move to new surroundings? Is he frank and open, easily expressing his needs and opinions, or is he inhibited, "shut in"? Is he trustful, or suspicious; stubborn, tactless, and faultfinding, or is he cooperative, compliant; sensitive or calloused; selfish or generous; sympathetic or wholly self-centered?

Perhaps the most obvious dichotomy in personal relationships is that between the self-assertive, dominant, aggressive, courageous, type of individual, and the one who is self-depreciative, retiring, submissive. Traits frequently associated in this latter type of personality are: a marked tendency to criticize others, a hidden stubborn resistance (with outward compliance), marked sensitive-

ness to criticism (with the tendency to feel slights where none were intended), dissatisfaction, jealousy. The cautious clinician, however, will not assume the presence of any of these traits without factual basis, and he will not permit any preconceived notion of a "type" to prejudice his observation in a given case. It is this ability to avoid "halo effects" that marks the accurate observer; it is all too easy to allow the presence of some outstanding "good" or "bad" trait to influence the rest of one's estimate of the person.

Other traits which may be noted here are: frankness (willingness to reveal much of his inner life) or reserve, conscientiousness or carelessness, honesty or tendency to deceive, egotism or humility, demonstrativeness or "coldness," the presence or absence of marked family attachment (as revealed, for example, by unusual behavior at the death of or separation from members of the immediate family).

Viewed from another angle, the person may be described as self-sufficient or as markedly dependent upon others. The latter individual needs the support of a surrounding social group, and is lonely, isolated, "lost" without such contact. Both in their concern about the impression they are making upon others and in their need for affection, and praise, individuals vary widely. Other factors which may be studied are: ability to take advice or criticism, suggestibility, the tendency to dramatize or pose, the presence or absence of curiosity about others.

Throughout the study of the personality (and if we risk too frequent repetition of this emphasis it is because of a real danger) it is important "to show wherein" a trait is present. Sensitiveness, honesty, dominance, and inferiority are names for classes of situations; the trait should not be assumed to be present or absent, however, in all situations of a given type. The "inferior" person is seldom universally so; and sensitiveness is greater in some situations than in others (and it would still be much more helpful to have a clear idea of the nature of the sensitive areas than to have a single quantitative index of the amount of sensitiveness even were the latter possible).

Attitude toward the self. Strictly speaking, the attitude toward the self cannot be separated from the attitude toward others. We deal with a bipolar relationship in which a change in either of the two members constitutes a change in the other. But it is important to realize that the individual's estimate of himself

may vary widely from the estimates of his fellows, and that the impression he creates upon others may not at all agree with his own estimate (or intention). Where this gulf is too wide we speak of a lack of "insight," and we should regard it as a distinct handicap in the individual's attempt to adjust to social reality. Thus, a feeling of inferiority, the feeling that one is physically unattractive, the feeling that one is unjustly treated, and similar self-estimations may play an important role in one's conduct without having any good factual basis (and without being apparent to the casual observer). Such self-estimates may be difficult to uncover; in fact, they may be so hidden from the individual himself that only prolonged study can reveal them.

Even in the less obscure aspects of personality this same type of discrepancy appears. The individual's estimate of his own health and available supply of energy may be quite faulty, and one thinks of the two extremes here: the individual whose lack of concern borders upon neglect, at one extreme; the hypochondriacal, overconcerned individual for whom the slightest bodily symptom becomes the object of anxious consideration, and who constantly underestimates what he can tolerate, at the other.

The same extremes of self-estimation recur in the ethical sphere. There is the individual who is extremely self-critical, harsh in his judgment of himself (and usually of others). At the extreme his obsessive need of perfection never gives him peace of mind; the failures which the rest of us would consider as humanly unavoidable are to him inexcusable. And at the opposite pole is the individual who so easily excuses himself, who so readily forgets his shortcomings, that his fellows feel he lacks the commonly accepted standards.

All these estimates are made against standards, held more or less explicitly. Although we may glibly generalize, and say that all such standards are of social origin, the individual's participation in such a social heritage is, after all, a unique thing. It is important to know the ruling criteria against which the individual characteristically estimates himself and others (*e.g.*, moral, religious, aesthetic, economic, etc.). Does he evaluate his acquaintances chiefly on the basis of their intellectual qualities, or in terms of some privately held judgment of what constitutes social status (family, wealth, participation in some "genteel" tradition, etc.)? In this connection one should note the individual's need for order, his standards of neatness, tastes for personal adornment, arrangement of his home, etc. What are his pecuniary standards: is he inclined to be penurious, cautious in making investments, worried over expenditures, or does he spend freely (and often beyond his means)? Does he show a marked need for pleasure, amusements, and does he tolerate such pursuits in others; or does he consider such activities a waste of time, if not positively sinful?

What are his aesthetic needs, and how do they find expression? Can he create aesthetic values? Does he approach an aesthetic

object with an attitude of enjoyment, or are his aesthetic interests markedly intellectualized? Or is he, like the stamp collector, prone to consider the rarity of an item the measure of its values?

What are his religious needs, and to what extent are his thoughts and actions dominated by semimystical or magical practices? Is he superstitious, or interested in the occult? Is he totally unimaginative, engrossed in the practical? Does his attempt at a synthetic view of reality limit itself to the scientific-philosophical type of construction?

Sexual Behavior.—There is no logical reason for making the individual's sexual behavior a separate object of study; but its clinical importance in these post-Freudian days merits a special word. Because of our rather rigid codes in such matters, deviations from the norm are flagrant; and as a result, frankness in facing sexual problems is all too rare, repressions, secretiveness, anxieties, and lack of insight, all too common.

In addition to the outstanding and more obvious facts in the individual's sexual history (age of adolescence, married or single, children, etc.), the clinician is interested in discovering the individual's attitude toward his own and the opposite sex, his frankness or secretiveness in sexual matters, whether or not he is shy in the presence of the opposite sex, the number and nature of his love affairs, his intolerance or disgust for sexual topics, modesty and prudishness (as well as any special demands for neatness and cleanliness), or tendency to moralize. He will be interested in any tendency to postpone marriage or engagement, and in the individual's reactions to disappointment in love. If the individual is married, he will wish to know something about the success of the marital adjustment (in detail), whether there is a normal desire for children, whether sexual demands are great or small. Perversions and abnormalities (impotence, frigidity, homosexual tendencies or attachments, etc.) will necessarily be investigated. Of equal importance to the presence or absence of masturbation in the sexual history (a not uncommon finding) is the individual's reaction to this problem, as well as his method of dealing with the question of continence. His capacities for restraint and his ability to manage his sexual needs, the extent of his information and the manner in which it was obtained, the number and type of situations which arouse him sexually, must all be investigated.

Synthesis of the Personality Data.—When the detailed study of traits has been completed to the best of the clinician's ability, the

most important task remains: that of evaluating, weighting, and unifying his findings. His interest is the practical one of the human engineer, and he is called upon, finally, to give specific advice and direction to the individual, advice directed toward the management of a specific life situation. This summation of assets and liabilities, and the pointing of lines of attack, requires a kind of practical wisdom of men and affairs—there is no mechanical substitute. The personality data cannot be placed in a tabulating machine in such a way that an index number or a diagnostic formula will emerge. As an artist works within a certain medium, making skilled use of his materials, the skilled clinician has to deal imaginatively and creatively with the materials he has discovered. He seeks a way of harmonizing conflicting trends, of eliminating conflict, of utilizing the specific assets to counterbalance the liabilities; and he seeks to increase the individual's self-knowledge wherever this can further a more rational and intelligent management of his own affairs. And in the presentation of his diagnosis, and in his attempts to influence his subject, he must be guided by the findings which he has achieved, utilizing what he has found to further more desirable integrations.

There is much about this process of summation and diagnosis which reminds one of the Gestalt description of the perception process. Out of a conglomerate of facts an organization must be made. Like Maier's reasoner who sees the problem (page 586) as "arm-too-short," the subject's assets and liabilities assume dynamic properties when seen against the background of his life situation and when viewed in connection with the problems he is trying to face. Like Claparède's subject who looks back and forth, fixating the various items in the picture-to-be-named, the clinician—with experience—surveys his findings, and the diagnosis arises.

In balancing one trait against another, in viewing traits-in-relation, in evaluating the items in relation to age, social status and background, sex, and in weighting constitutional and environmental factors, the clinician strives to achieve a total impression of the person. His best defense against the charge of subjectivity is in his painstaking search for factual material upon which to base his estimate; and when, in addition, his judgment is founded upon wide experience it will afford us—with all its shortcomings—the best available criterion against which to check our other methods of studying the personality.

Questionnaires and Rating Scales

The questionnaire method represents the attempt to arrive at a reliable index of personality traits through a standardized set of questions. It is less time consuming than the clinical interviews, it presents a uniform stimulus to the subject, and its results may be expressed quantitatively. Where the psychoanalyst would spend five hours or more weekly with a patient over a period of a year and a half—and still feel puzzled about many of the underlying motives for his conduct—the questionnaire permits the examination of hundreds of subjects in a relatively brief period. So easy, in fact, has the questionnaire approach seemed that their number is now legion. "Tests" which purport to reveal seclusiveness, self-confidence, emotionality, sociability, aggressiveness, introversion, masculinity, neurotic tendencies, submissiveness, suggestibility—to name but a few—have been applied to samples of the population. Rather elaborate statistical procedures have been utilized to measure the interrelations of the different traits, their distribution in the populations studied, the reliability and validity of the tests themselves. Frequently the statistical devices have seemed more elaborate than the nature of the data warranted; and mathematical ingenuity has sometimes served to compensate for what appears to be a lack of psychological sagacity.

At its best, the questionnaire yields a rapid and reliable self-portrait, and this in itself is an important achievement. It provides source material for further study and evaluation. When the questions are directed toward rather simple, factual material, and where the investigator is directly interested in such self-portraits, there is probably no more convenient method of study.

As an example of such questionnaires we may quote from one of the earlier investigations, carried on during the World War and directed toward the study of emotionality. The questions making up the "psychoneurotic inventory" were intended to sample the subject's emotional reactions, and the hoped-for result was to be the selection-in-advance of those soldiers who were most likely to succumb to the nervous and mental strain of trench warfare. For example, the subjects were asked:

Do you usually feel well and strong?
Are you frightened in the middle of the night?
Do you have nightmares?

Did you ever have dyspepsia?
Have your employers generally treated you right?
Did you ever have the habit of biting your fingernails?
Etc., etc.

A number of such questionnaire-inventory scales have appeared but they have proved to be of limited usefulness. A study of the Bernreuter scale by Landis and Katz[1] showed that, in particular, low scores on the test need not mean freedom from neurotic tendencies. A flat contradiction between the answers of the patient and those of his relatives (or the facts of his personal history) may exist. (One of the subjects, an elated manic patient, stated that she was not excited.) While in general the group which has been clinically diagnosed as neurotic will make high scores in such tests, neither high nor low score has sufficient predictive significance for the individual, nor is it necessarily an indication that psychiatric help should be sought. This does not mean that we shall not in the future be able to construct tests which will be of great psychiatric value; but it does argue against undue reliance on such questionnaire findings and for the need of extended research in the perfection of such instruments. Where the "normal" occasionally achieves high scores and the psychiatric patient can achieve a low rating, we can understand why the clinician has found little use for such scales.

Two types of rating scales may be briefly described. The one seeks to achieve an index number for traits which are otherwise incommensurable. Thus, a rater may be asked to estimate a person's effect as a social stimulus as follows:

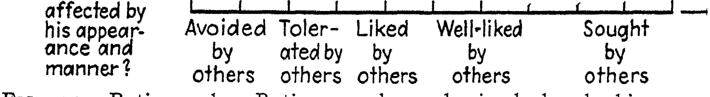

FIG. 110.—Rating scale. Ratings can be made simply by checking a point on a scale to indicate his opinion of the subject The dash at the end means "no opportunity to observe." (*From Ross Stagner. Psychology of Personality, p. 22.*)

As a technique to force the rater to make more accurate and specific statements something can be said for it. It may help to sharpen hazy impressions.

[1] Landis, Carney, and Katz, S. E. The validity of certain questions which purport to measure neurotic tendencies. *J. appl. Psychol.*, 1934, 18, 343–356.

A second type of rating scale makes use of concrete "standards" rather than abstract verbal definitions. A commanding officer in an army post might wish to rate his candidates for promotion to noncommissioned officer ranks. He could then set up as his "standard" an outstanding "noncom" (or candidate with the best qualifications). He may never formulate exactly what qualities have determined his judgment but with this standard he may then pick the least likely candidate, and then gradually fill in the ranks with the remaining applicants. New recruits could then be placed against this empirically constructed scale.

Stagner[1] summarizes the weaknesses of the rating-scale technique in pointing out that (1) the various judges may have their own private (and varying) conception of what constitutes a given trait, (2) they may have different notions of what constitutes the "average" amount of a given trait (cf. Landis's findings on estimations of weight and height) and (3) ratings are subject to a "halo effect." This last item refers to the fact that a person about whom we have a high opinion, in general, tends to achieve a high rating in all traits listed. The effect of an outstanding and valued trait will spread to adjacent items. Ideally, ratings for the different items should be made at different times. The most obvious correction for the first two shortcomings lies in accurate definition of the traits, and the constant attempt to force the rater to specify situations in which the trait is present or absent is a step in this direction.

Evaluation of Questionnaires and Rating Scales.—A word or two by way of summary and evaluation may be of some value, especially in view of the vogue of questionnaires and the contradictory attitudes displayed toward them. On the one hand, the psychologist interested in tests and measures, in quantitative indices, is likely to be unfavorably disposed toward what he sometimes facetiously calls the clinician's "bedside manner"; that is to say, he reacts against a kind of medical "impressionism." On the other hand, the clinician sees the test as measuring surface attitudes which have little relation to psychiatric reality. He reacts against what he sometimes feels to be a worship of numbers, and likes to emphasize the contradictory character of the findings of different testers.

Perhaps the first step in wisdom is to remember that there is no necessary correlation between the subject's statements and the

[1] Stagner, Ross. *Psychology of personality*, p. 22*ff*. New York: McGraw-Hill, 1937.

subject's behavior. He may misunderstand the question, he may wish to conceal information, he may have forgotten details of his own past, he may simply lack the necessary insight, he may present the rationalizations common to his social group and warp his description of his own conduct toward the socially acceptable norms, his answer to any given question may be influenced by the preceding ones, and his attitude toward the examiner will influence his whole performance. It is well, therefore, to understand that there are limitations to questionnaire data. One does not get from them a diagnosis of underlying causes. Alexander points this out rather forcibly in commenting upon a questionnaire dealing with marriage relations. A study[1] based on the answers of 372 subjects can be proscecuted by the questionnaire method in the course of a few months, but an extended psychiatric study of the individuals involved would mean about half the lifework of a physician.[2] In addition, the questionnaire method will not even reveal what the individual *thinks* is wrong with marriage; it reveals what he is willing to *say* is wrong with it. He probably does not know all the factors in his own case. Consequently, when we add up our ratings on the different questions we may fail altogether to discover the truly significant items.

If we remember the limitations attached to this type of "self-portrait" and if we do not hastily extend our results beyond the individuals (or population samples tested), the questionnaire may serve as a useful exploratory tool.

Tests which Approximate the Life Situation.—Partly as an attempt to bridge the gap between words and conduct, and partly as a method of extending the study of personality down to the lower age levels, a number of tests have been devised in such a way that critical samples of the subject's behavior can be directly studied under standardized conditions. Thus, the psychoanalyst studying "sibling rivalry" in children may make use of dolls to dramatize the family conflict. The child is told, with appropriate placing of the dolls, that one represents the new baby at the mother's breast, and that the sister (or brother) now sees it for the first time. What

[1] Hamilton, G. V., and McGowan, K. *What is wrong with marriage.* New York: Boni, 1929.

[2] Dr. Alexander estimates that it would take twenty years. Alexander, Franz. Evaluation of statistical and analytical methods in psychiatry and psychology. *Amer. J. Orthopsychiat.*, 1934, 4, 433–448.

will the child do? According to the account of one investigator, his aggressive-possessive behavior, his guilt, and his defenses and compensations for these are freely expressed in the resultant behavior.[1]

Marston[2] utilized an experimental situation in his study of "introversion" in children, observing their method of approach to a toy held by the experimenter, their persistence in working at a latch-box problem which was too difficult for them to solve, and their willingness to accept a nonpreferred toy when the preferred one was in sight. Correlations between the behavior in these standard situations and the findings on a rating scale (0.52 for boys and 0.54 for girls) served both to validate and to interpret the scales.

One of the most extensive studies of this type was devoted to the question of children's honesty.[3] Children were sent on errands on which they were given more than the correct amount of change. They were given opportunities to cheat in a party game, an examination, etc. Throughout the study the children were, of course, kept in ignorance of the fact that honesty was being measured. One of the outstanding results of the experiments is the fact that performance in one test had little relation to performance in another. Such a finding raises the question as to whether one should speak of such a thing as "honesty in general." Like the older faculties which Gall and Spurzheim sought, this character trait is an abstraction. It is not a quality of behavior uniformly present in a certain degree throughout the behavior of a subject, but is rather the quality of specific situations. Thus, a child might cheat in an examination and be scrupulously honest in the test game; or he might return the change, cheat on his examination paper, but later tell the truth about his dishonesty.

It is interesting to note, in addition, that the index of the child's honesty bore little relation to his ethical information, to his having attended Sunday school, or to his teacher's ratings of this character trait.[4]

[1] Levy, David M. Use of play technic as experimental procedure. *Amer. J. Orthopsychiat.*, 1933, 3, 266–275.

[2] Marston, L. R. Emotions of young children. *Univ. Ia. Stud. Child Welf.*, No. 3, 1925.

[3] Hartshorne, H., and May, M. A. *Studies in deceit.* New York: Macmillan, 1928.

[4] Honesty ratings and honesty scores gave a correlation figure of 0.25.

Such findings have a distinct bearing on the whole question of "tests." We shall never escape the problem of understanding what the significance of the test situation is to the subject, and if the specificity of the honesty scores is borne in mind we shall never assign too great weight to any single type of test situation. It is possible that with older subjects greater consistency would appear, a consistency which would parallel the ability to think in abstract terms; but the studies of children imply that a trait such as honesty is developed in specific situations (if at all) and they warn us against assuming any consistency in behavior that has not been demonstrated.

Indirect Methods

Handwriting.—An ancient method of studying personality which has long been in ill repute in scientific quarters shows some signs of revival. A number of studies have brought forth evidence which purports to show that one's handwriting can be made to reveal significant personality traits. It has been found, for example, that where samples of handwriting are matched with brief but carefully drawn up personality sketches the number of correct pairings is much greater than chance would allow.

The Downey Will-Temperament test, utilizing a standardized writing procedure, attempted to draw out such traits as speed of movement, freedom from inertia, flexibility, speed of decision, motor impulsion, assurance, resistance, motor inhibition, care for detail, coordination of impulses. A "psychogram," showing the "profile" of the individual, was constructed on the basis of the findings. Such tests, however, showed considerable variability on repetition, and have never enjoyed wide usage.

When one examines the claims made for handwriting, and the clues which are supposed to be significant, one is inclined to remain skeptical and wait for more convincing proof. Consider the relationships suggested by Dr. Oskar Diethelm[1] as shown at the top of page 643.

Such a system (which closely follows the work of Klages)[2] would have a number of advantages. The permanent and easily available

[1] Diethelm, Oskar. The personality concept in relation to graphology and the Rohrschach test, Chap. 17 in Vol. XIV, *Proc. Ass. Res. nerv. ment. Dis.*, 1934, 14, 278–286.

[2] Klages, Ludwig. *The science of character* London: G. Allen, 1929.

Characteristics of Handwriting	*Traits to Be Inferred*
Regularity: balanced spaces	Ability to deal with personality factors which interfere with purposeful activities (Depends on the one hand upon volitional endowment, and on the other upon the intensity of the interfering factors)
Stability (?)	Emotional stability
Pressure	Degree of excitability
Speed	Speed of emotional flow (?) Supply of available energy
Size	Tendency to display. Self-confidence
Width	"Restraining factors of the conscious self"
Scrolls, elaborations	Need for (and type of) self-expression
Slant	Social feelings, coolness, aloofness
Sharpness of letters	"Instinctive closeness to nature," and ability to let oneself go
Clear-cut and well-connected word units	Self-preservative tendencies
Closeness of letters	Logical and associative tendencies
Relationships of lengths	Ability for abstraction and concreteness
Fullness of letters	Sharpness of thinking and type of imagination
Simplification	Orderliness of thinking

samples of handwriting would permit verification, long-term studies of the constancy of the personality, studies of relatives of the patient, etc. But the whole conception lacks empirical foundation, and it is far too close to the whole faculty psychology (and phrenology) for comfort. The student of handwriting cautions us, to be sure, against attempting a too-simple translation (trait for trait) and against any attempt to achieve mathematical accuracy through measurement. He believes that it is necessary to rely to a great extent upon a general impression, and to consider traits-in-relation always. This leaves us with both terms of our relationship (handwriting and personality trait) in a rather hazily impressionistic status. It is doubtful if, in another field where there are good objective standards for validation, such a method could find a scientific hearing for more than the briefest period.

It is true that our personality writes its effect into each of our acts (is it not the sum total of our acts which *constitutes* personality!); but some are vastly more revealing than others, and it is likely

that handwriting is one of the lesser clues. For one thing, it is subject to so many specific "external" factors. The prevailing methods of teaching in the schools, the family "model," the pressure for speed (which causes the breakdown of the writing habits of so many college students), and the physical characteristics of the writing member all affect the handwriting, and all seem more or less external to the structure of a personality.

Free Association Methods.—A modification of Jung's free association technique, which records motor responses, both voluntary and involuntary, as well as the verbal reactions, has been used to explore the emotional reactions of the person, to unearth "complexes" which may be hidden from the subject himself. While the words of the Jung list are presented to the subject his two hands rest lightly on recording tambours. He is instructed to associate to each of the stimulus words with "the first word that comes into his mind" and at the same time to press the right-hand tambour, the left hand remaining in place. At least two neutral words are usually placed after each critical word so as to "absorb" persisting tensions. Reaction times for both verbal and motor responses may be automatically recorded, as well as evidence of involuntary responses (left hand) and any motor disorganization. The theory lying back of such procedure assumes that the emotional responses disorganize the reaction set, and experimental evidence supports this assumption. Where a great deal is known about the subject's background and experience such a test can be made even more revealing by the addition of critical words which are adapted to the individual subject.

Dr. Franklin Ebaugh, who has utilized this method with psychiatric material,[1] has been able to show certain characteristic differences between the diagnostic groupings. In the psychoneuroses anxiety is shown in a generalized tension and motor disturbance. The hystericals and obsessive-compulsives show more sharply localized effects. Short reaction times characterize the manic patient, and long reaction times the depressive type. The schizophrenic patient, besides showing pronounced disorganization, gives bizarre verbal associations, blocks at critical words, and in general gives a variable reaction. Besides giving an objective record of performance which can be studied in detail, Dr. Ebaugh reports

[1] Ebaugh, Franklin G. Association-motor investigation in clinical psychiatry, *J. men. Sci.*, 1936, 82, 731–743.

that such a demonstration helps the patient to accept emotional causes for his illness which otherwise might be rejected. It is interesting to note that the experimenter finds that the degree of disorganization of response declines with successful therapy.

For the normal subject such a method of exploration will furnish interesting material for further study, it will give concrete evidence of a number of "sensitive areas," and it can be made to reveal aspects of the personality which the subject cannot (or will not) otherwise discuss. The method is not a way of achieving a diagnosis, nor of "typing" subjects, but is rather to be viewed as an exploratory technique.

The Rorschach Test.—Hermann Rorschach, a Swiss psychiatrist and psychoanalyst, devised a test (1911) similar in some respects to the association test but utilizing as stimuli a set of ten ink-blot charts instead of the verbal material. Some believe that the ink blots have an advantage over the verbal type of stimulus in that the responses are more spontaneous (and *revealing*, since they are less determined by the verbal habits that are a common heritage in our culture). The ink blots are formless in the sense that clouds or the flames of a campfire are formless, and much as the daydreamer "reads into" such shapes his fantasies, the Rorschach subject gives interpretations of the blots that are more or less revealing. Rorschach was interested in the subject's *method of perceiving* the forms, the *quality* (whether form, movement, or color—and in what combination), *content*, and *originality* of the responses. The test can be administered in most cases within a half hour or less, and with standardized procedure the results are fairly reliable.[1]

The interpretation of the findings and the establishment of their validity pose more difficult questions, however. Unlike the American statistical studies, Rorschach analyses are qualitative rather than quantitative, and a large subjective element enters into the evaluation of the scores; their mutual interrelations and their position in the setting of the *total* personality receiving great emphasis. The "types" which this test reveals have not shown any high degree of correlation with other measures, and there is considerable dis-

[1] Hertz, M. R., found coefficients of reliability ranging from 0.90 to 0.60. (The reliability of the Rorschach ink-blot test. *J. appl. Psychol.*, 1934, 18, 461–477.) Vernon, Philip E., with less standardized procedure and slightly less objective scoring, obtained coefficients ranging from 0.33 to 0.74. (The Rorschach ink-blot test. *Brit. J. med. Psychol.*, 1933, 13, 89–118, 179–200, 271–291.)

agreement among those who use the test as to the significance of the scores on the individual items. The most that can be said at the present moment is that the test offers interesting possibilities. Vernon, who is sharply critical of the test's shortcomings (particularly its low reliability—in his findings—and its lack of proper norms and validation), says, nevertheless, that he knows of no personality test that will yield an equivalent insight into the personality of a subject within so short a time.

We can gain a better notion of the nature of the test if we examine briefly some of the items which Rorschach believed to be significant:

Mode of perceiving. The subject may see the blot as a whole, or may react to details; or he may do both, proceeding from whole to part or in the reverse direction.

In the latter case he may have many details well seen and appropriately fitted together, or he may have but few details and the whole may be warped to the parts (confabulatory secondary *Ganzheit*). He may note details on the white background instead of as in the usual manner. Where wholes are commonly seen but only details reported (as when men are commonly seen, but in this case just the heads reported), Rorschach thought he saw evidence of defective intelligence. From these methods of perceiving Rorschach believed that he could determine whether the subject was of an analytic or a synthetic turn of mind. Too many whole-responses indicated, he thought, a lack of practicality. The number of whole-responses indicated "richness of association," but if these are always primary, a philosophical-artistic turn of mind is suspected in addition. If the detail-responses predominate slightly, it indicates a practical turn of mind, ability to handle details; but if too many are present, it indicates pedantry, small-mindedness. If the sequence of responses to the different blots is rigid, fixed stereotypy and meticulousness are indicated; if wholly irregular, an illogical or disordered mind.

Quality of response. Forms seen by the majority of subjects are counted "well seen." (In the absence of adequate norms, this has been a source of confusion in the past.) A high percentage of well-seen forms indicates intelligence, too high a proportion indicates a tendency to be hypercritical and pedantic. *Movement responses.* The more intelligent subject sees a larger proportion of moving forms, and Rorschach speaks in this connection of an intrapsychic creativity and productivity. Artistic subjects show more of these in contrast to those who are materially minded. (Vernon lists pedants, melancholics, catatonic and hebephrenic patients, imbeciles, in this latter category.) Where the moving figures are bent and contracted the subject is supposed to be of the passive (or neurasthenic) type; the erect figures indicate active and energetic traits. *Color responses.* Occasionally in some abnormal subjects the first color card will produce a marked inhibition, or "color shock." Art students were found to note color more frequently. In general, the color responses are a measure of emotionality (*e.g.*, the depressed patient—for whom the world is gray—fails to note them). Where color predominates over form impulsiveness is suggested,

the form element corresponding to a volitional element. Color-predominant responses, therefore, indicate suggestibility, lability; while the form-predominant ones suggest better adaptation of emotions to practical and social ends. A predominance of black and of responses which depend upon reaction to shading are thought to indicate anxiety, fear, uneasiness. (There is some experimental evidence to the effect that this indicator appears where other physiological measures—*e.g.*, sugar tolerance—also suggest anxiety or fear.)

Content and originality. Rorschach counted any response not given by more than 1 per cent of the subjects as original. These may be good or absurd and reflect the quality of the subject's originality. Much care is needed in standardization at this point, for cultural and occupational backgrounds will assuredly affect the number of "atypical" responses. As yet such norms (*e.g.*, norms for the different occupational groups) are nonexistent, and investigators are left somewhat to their own devices. When original responses mount above 40–50 per cent of the total, a "fantasy richness" is indicated, and less than 10 per cent indicates low intelligence, lack of imagination. *Animal* forms, the most frequent type of response, are always listed, and indicate stereotypy. Artists were found to give few of these, listing more than the average number of human forms. *Object* responses were thought to indicate concrete, materialistic interests. *Complex material* relating to special interests, conflicts, preoccupations, receives attention similar to that accorded to any free association material. Sexual content, hypochondriacal brooding, fears, aggressive tendencies, may appear in the content of the answers. Some subjects (particularly the organic psychoses) tend to describe the blots instead of interpreting them.

Types. Rorschach was especially interested in the balance between emotional and intellectual forces in the individual, and he distinguished a number of types. *Extratensives* were the practical individuals with interests flowing freely into the outer world, and their responses showed a dominance of color reactions. The *introversives* (with more movement responses) were those whose interests were bound up in an inner world, in things of the spirit. The extreme form of the latter becomes too much bound up in fantasy and may be poorly adapted, while the extreme of the former type tends toward a flighty, unstable form of activity, and toward the routine and reproductive rather than the inventive type of intellect. *Ambiequals* show a more balanced distribution of traits. Also balanced, but on a different level, are the *coartives* (or "constricted" individuals) among whom he placed the pedants, melancholics, formalists, dogmatic scientists, and those who are notably lacking in artistic talents.

It is difficult to predict what will come of the Rorschach type of test. The types which Rorschach was interested in have not found wide favor, and his measures have not been found to correlate with other "type" tests which, in verbal description at least, seem directed toward a similar differentiation. His measures of intelligence show a low correlation with the standard psychometric examinations. One cannot escape the general impression that a similar amount of energy expended in the direct study of the person

would yield more significant data. Certainly, in its present experimental stage it is no substitute for such study.

The Study of Fantasies.—A method which bears some resemblance both to the free association technique and to the Rorschach test is proposed by Dr. H. A. Murray.[1] A subject who is ostensibly taking an "imagination" test is given pictures portraying dramatic situations and is asked to weave a story about the picture. The pictures are selected so as to cover a wide variety of situations and so as to provide characters with whom the individual can easily identify himself. It has been found that the "themes" which are developed are in no sense sheer inventions, but bear, instead, a close relation to the subject's needs and experiences. Deep-seated tendencies (of which the subject may be unaware) may thus come to the fore and something of the "dynamics" of the personality may be shown. Such investigations are qualitative, rather than quantitative, and are as yet in their preliminary stages. Coupled with other more direct discussions of the material they reveal, they may provide a useful weapon in the armamentarium of the student of personality.

Types of Personality

Introversion and Extroversion. *Jung's Description.*—One of the most frequently used descriptions of the personality is the trait introversion, or its opposite, extroversion. Jung, who did much to give currency to the terms, describes the introvert as governed by subjective factors, as regarding his own "inner world" as of more importance than the world without. Instead of striving ever to achieve the approval of the flesh and blood persons who constitute the immediately proximate social group about him, he seems governed by an "unseen host," and to have his own private standards—and to this degree to be inaccessible. Commonly described as a "shut-in" type, the introvert seems to have reared elaborate defenses against the intrusion of the outer world; he is more absorbed in his daydreams than in the world of social reality—which latter world he often regards as of little significance. On the surface he seems merely bored with the outer world, but often, and perhaps always, he finds it brutal, terrifying. Possibly his fear is the principal motivating factor which leads him to rear such complete defenses against reality. He is like the person who refuses to entertain great hopes

[1] Murray, H. A. *Explorations in personality.* New York: Oxford, 1938.

for fear of meeting with disappointment. His conscious depreciation of external reality is both a rationalization and a defense; it throws a line of defense around the individual and helps to maintain at least the illusion of superiority and (however false) a sense of security. By placing our treasures where moth and rust do not corrupt we endeavor to escape a certain amount of worry over the objective process of decay.

And yet this "flight from reality" is never wholly successful. Reality is insistent, and pressing. He can escape it no more than the Christian Scientist can escape the ravages of tuberculosis. And he is continually caught off guard; the orientation which he preserves (to a fictional world) does not prepare him for the real events which he must meet. Situations continue to menace him because he has persistently avoided the development of the very skills which he needs to meet them; and his tendency to become personal, to take offense easily, shows the flimsy character of his defenses. He deceives himself, apparently, more readily than he deceives others. The very forces which have driven him "within himself" continually upset him. The hand extended in greeting startles him as though it were a doubled fist in the act of striking. The casual remark, the jest, is felt as abuse. This touchy, thin-skinned individual is difficult to live with. Others who would mollify him find the task burdensome; and as a result his social difficulties are intensified. The introverted child becomes an easy butt for the tormenting of his thicker skinned playfellows. The inadequacy of his defenses may result in a further withdrawal, and if this occurs a circular process is set up: the inadequacy of the defenses initiates further withdrawal and this in turn deepens the difficulties, widens the barrier between the individual and social reality, etc.

According to Jung, this differentiation into types may be marked so very early in life that it may be considered as innate. Whereas the extroverted child is blissfully trustful, interested in objects, is not fearful, is willing to take risks, the introverted child is pictured as timid, anxious, resistant to outside influences, and distrustful of whatever is unknown. He requires constant assurance, needs names and explanations as though for protection against this threatening outer reality. McDougall,[1] likewise, regards these types as constitutionally determined (*i.e.*, as inherited), and refers

[1] McDougall, William. *Outline of abnormal psychology*, p. 442. New York: Scribner, 1926.

the type to some "general property of the nervous system" which is in turn related to "some chemical product or products of metabolism," or possibly to some hormone or endocrine secretion. McDougall, however, does not believe that we can speak of hard and fast types, and is willing to conceive that environment may modify these types to some extent.

Allport's Interpretation.—Allport, while agreeing with the general description of the type, finds another explanation for the traits of the introvert. Instead of seeking the explanation in some chemical, constitutional, or innate factor, Allport finds it in the inhibiting circumstances which confront the individual. Normally, when we are blocked, the motivating stream of energy overflows to the viscera; we are angry, or we struggle, and our overt actions increase. But when the blocking is effective enough we avoid the inhibiting stimulus, embark in compensatory struggles, or replace the overt adjustment with an internal one.[1] The situation which gives rise to thinking is, after all, precisely the one here described; when the overt adjustments that we have at our command do not work, when the situations confronting us are too difficult, then we are thrown back upon ourselves. When in our daydreams we thoroughly trounce the opponent who has been too much for us we show this "introvert" trick. The disturbance generated at the time of the encounter did not subside at once. The stream of images gives conscious expression of its continuing potency. Now, the difference between this "normal" trick and the extremes of introversion is one of degree and depends upon the completeness of the thwarting and upon the fact that the daydreaming of the introvert does not serve to lay the basis for a return engagement with reality, but rather as a substitute for such an engagement. The introvert is not merely more thoughtful; he is inclined to substitute thought for action completely.

Thus, we might, following Allport, explain the tendency of the adolescent to daydream. When adult responsibilities must be met with a childish equipment, when new problems descend at a rate exceeding new skills with which to meet them, we need not be surprised that daydream solutions should occupy a great place. It is when the failure to meet difficulties is not admitted, and when the individual instead of attempting to strengthen his weaknesses tries to achieve some imaginary victory, that the vicious cycle is instituted.

[1] Allport, F. H. *Social psychology*, p. 116. Boston: Houghton, 1924.

In his description of the introverted school child J. J. B. Morgan[1] lists the following specific characterizations, which help to make the picture of the type a concrete one: He is the model pupil, the "goody-goody" child, who keeps his clothes clean, who is never punished, who seldom fights. In the eyes of the other children he lacks "pep" or "spunk." He likes to work alone, would rather read than be with others, is not inclined to participate in community enterprises. His queer emotional reactions indicate his preoccupation with his own peculiar inner world.

It is clear that there is some divergence of opinion concerning the causation of the type; but so long as the description remains at the literary level it is possible to get the impression that the type itself is fairly well defined. As one reads the literature on personality, however, it becomes apparent that the outlines are rather vague: there are differences in emphasis, and occasional conflicts emerge. For example, Morgan describes the introverted child as keeping his clothes clean longer than other children, but adds that he is careless about his person, lacking initiative to get dirty, and lacking spirit to take interest in making himself neat. There is the further fact, attested by both common observation and experimental studies, that such traits as neatness are seldom so generalized as to be found in all spheres of activity in the same degree. A child may be neat in personal appearance and keep an untidy room. And he may be expansive in one social group and shy in another. One gets the impression that the terms "introvert" and "extrovert" have come to be rather loosely applied epithets. Before they merit serious consideration they need to be more sharply defined. Moreover, if most of us show a mixture of extrovert and introvert tendencies, before we can measure our position on an extroversion-introversion scale, the traits must be objectified, that is, described in terms of specific performances.

An Empirical Approach to a Definition of the Types.—One of the early attempts to delimit the terms was made by June Downey,[2] who sent a questionnaire to members of the American Psychological Association, asking them first, to rate themselves as extroverts or

[1] Morgan, J. J. B. *The psychology of the unadjusted school child*, p. 134. New York: Macmillan, 1924.

[2] Downey, June. How the psychologist reacts to the distinction "extrovert-introvert" with observations concerning lateralization of function. *J. abnorm. (soc.) Psychol.*, 1926, 20, 407–415.

introverts, and then to explain why the rating was made. Of those who replied,[1] the introverts listed the following reasons for their self-rating:

1. Frequency of self-reference. Egocentric tendency. Under this heading were classified such characterizations as: overconscientious, defensive, tendency to become personal in social relations, given to self-examination, tendency to brood over little things, more affected by self-approval than by approval of others, interested in "inner life" and things of the spirit, interested in self rather than in work, introspective, sensitive, self-depreciative.
2. Failure to make social contacts easily, self-sufficiency. This category included such observations as: not a good mixer, difficulty in meeting people and in appearing in public, light conversation with a stranger difficult.
3. Tendency to become more interested in ideas, theories than in actions, things. For example: interested in theory rather than in its application, would rather think than express, ambitions and daydreams so much greater than expression and accomplishment.
4. Difficulty in getting into action.
5. Introspective tendency. Daydreaming.

The extroverts who replied stressed a group of traits which lie at the opposite pole:

1. Absence of self-reference or egocentric ideas. For example: does not subject self to critical self-examination, seldom thinks of effect of action on himself, life and its objects taken externally, takes attitudes of others readily in self-judgment, not oversensitive, no undue self-analysis, interests in the external world.
2. Ease in making social contacts, social interests. For example: not contented to work alone, likes to teach, a moderate tendency toward display, active in social organizations, sociable, talkative, interested in social problems, too ready response to social demands, interested in others (their interests, experiences, etc.).
3. Greater interest in things than in ideas, theories.
4. Interested in action, aggressive. For example: a strong drive toward getting things done, prefers to act rather than to think, plan, or feel, avocations in bridge, golf, and athletics rather than in music, reading.
5. Tendency to face reality. That is to say, willingness to face actual situations and deal with them rather than to rationalize, to attempt to shut out the world, or to reconstruct it in daydreams.

Such a questionnaire method of arriving at the meaning of psychological terms leaves something to be desired. There is no guarantee, for example, that, although the traits are listed in the order

[1] A number declined, regarding the whole business as mythology, a silly business, of no particular significance. Others insisted that all of us are mixed, anyway, and that the concepts are of no significance save in the abnormal extremes.

of frequency with which they were named, there is any internal consistency in the picture which results. Nor are the traits, as presented, satisfactory for the one who wishes a psychological measuring stick. Such traits as "tendency to face reality" and "greater interest in things than in ideas" are both difficult to evaluate and to apply in any concrete instance. We are still very much at the impressionistic stage.

Heidbreder's Study.—To obviate this difficulty Heidbreder[1] drew up a list of items dealing with more specific performances and applied them to a group of subjects where self-ratings could be compared with the ratings of associates. Of her list of 54 items, the following 31 traits are representative and most clearly differentiate the two types. The groups of traits can be shown to have some type of internal consistency, for statistical measures show that each trait does what the list as a whole does; that is to say, at the extremes these traits tend to cluster and be present en masse.

1. Limits his acquaintances to a select few. (This may be beyond his control.)
2. Feels hurt readily; apparently sensitive about remarks or actions which have reference to himself.
3. Is suspicious of the motives of others.
4. Worries over possible misfortunes.
5. Indulges in self-pity when things go wrong.
6. Gets rattled easily; loses his head in excitement or moments of stress.
7. Keeps in the background on social occasions; avoids leadership at social affairs and entertainments.
8. Is critical of others.
9. Prefers to work alone rather than with people; prefers to work at tasks that do not bring him into contact with people.
10. Has ups and downs in mood without apparent cause.
11. Is meticulous; is extremely conservative about his dress and painstaking about his personal property.
12. Blushes frequently; is self-conscious.
13. Pays serious attention to rumors.
14. Expresses himself better in writing than in speech.
15. Resists discipline and orders.
16. Limits his acquaintances to members of his own sex.

[1] Heidbreder, E. Measuring introversion and extroversion. *J. abnorm. (soc.) Psychol.*, 1926, 21, 120–134.

17. Avoids all occasions for talking before crowds. Finds it difficult to express himself.

18. Is a radical; wants to change the world instead of adjusting himself to it.

19. Is outspoken; says what he considers the truth regardless of how others may take it.

20. Introspects; turns his attention inward toward himself.

21. Prefers participation in competitive intellectual amusements to athletic games.

22. Is strongly motivated by praise.

23. Daydreams.

24. Is selfish.

25. Dislikes and avoids any process of selling or persuading anyone to adopt a certain point of view (except in the religious field).

26. Is sentimental.

27. Is extremely careful about the friends he makes; must know a person pretty thoroughly before he calls him a friend.

28. Shrinks from actions which demand initiative and nerve.

29. Talks to himself.

30. Derives enjoyment from writing about himself.

31. Keeps a diary or journal.[1]

Two hundred college men and women who were given the test made, on the average, a slightly extroverted score (−11.12 when all 54 traits were considered). While there was no difference in the average values for men and women, there were some sex differences in the traits checked.[2] Women, for example, were more apt to confess to ups and downs in mood without apparent cause, to feel hurt readily, to dislike and avoid any process of selling or persuading, etc., to worry over possible misfortunes, to keep a diary. Men are more apt to assert that they are outspoken, keep in the background on social occasions, prefer participation in competitive intellectual amusements. Miss Heidbreder raises the question as to whether the differences noted are the outcome of popular stereotypes (we tolerate certain traits in one sex and not in another) or whether they represent true sex differences. Is the male, for example, really more outspoken, or is the picture of the "forthright" person in conformity with accepted masculine standards and hence apt to be checked?

[1] *Ibid.* Reprinted by permission from the Journal of Abnormal and Social Psychology.

[2] Heidbreder, E. Introversion and extroversion in men and women. *J. abnorm. (soc.) Psychol.*, 1927, 22, 52–61.

In the Heidbreder test the subjects measured did not divide into two sharply differentiated groups but followed rather the normal curve of distribution with the bulk of the cases midway between the two extremes. According to this test, therefore, most of us are ambiverts; or perhaps we should say that we are extroverted at times and introverted at others. This argues against the constitutional (chemical) interpretation and suggests that the training of the individual, his experience in particular situations, and the relationship between his own traits and talents and those of the members of the group with which he functions are the true determiners. These results are also closer to some facts of common observation. Consider the young woman who in her college years seemed quite shy and withdrawn from social life, and who later as a teacher to whom her charges look for guidance and leadership assumes a totally different role. Consider the boy who is a leader on the playground, whose voice can be heard above all the others, but who blushes and stammers in the classroom. It would seem that we are dealing with a plurality of selves, of selves which are functions of situations, relations.

The Neymann and Kohlstedt Test.—A second questionnaire test of introversion, devised by Neymann and Kohlstedt,[1] raises certain fundamental questions about the whole procedure. These investigators standardized their test questions by first applying a battery of 100 questions to patients in hospitals for the insane where the extremes of these personality types may be found. They sought in this manner to get some more objective criterion, similar to those available to the intelligence tester (mental age, school performance). After all, a list of traits founded upon mere hunch may measure something; but have we any right to call the resulting score an index of introversion? And will the hunches of another investigator result in a similar index? Now, the manic-depressive patient, at least in the manic phase of his illness, represents extroversion in the extreme. His excitability, talkativeness, flight of ideas, show little or no inhibition; the schizophrenic patient, on the other hand, represents (in some types at least) the extreme of the "shut-in" type. Using these two groups as standards, the investigators eliminated from their list of questions items which failed to differentiate between the two. A final battery of 50 questions was obtained.

[1] Neymann, C. A., and Kohlstedt, K. A new diagnostic test for introversion-extroversion. *J. abnorm. (soc.) Psychol.*, 1929, 23, 482–487.

Using this selected list (and they were selected on the basis of their ability to differentiate), the subjects were found to fall into two groups, a bimodal type of distribution, with but 12 borderline cases falling between scores of +10 and −10 (on a scale running from +50 to −50). Of these borderlines but two failed to conform to the criterion, a diagnostic failure of but 1 per cent.

Even more important for our purposes is the fact that this same test applied to 200 normal college students revealed a similar bimodal curve.[1] If the Heidbreder test measures introversion, then the Neymann and Kohlstedt does not, and vice versa. One could not conclude from an examination of the questions themselves that this second test measured different traits, for the general tenor of the questions appears the same. For example, the subjects were asked to report whether they liked or disliked to:

1. Be by yourself a great deal.
2. Always be calm and collected.
3. Think or dream of what you will do in five years from now.
4. Stay at home during a social affair.
5. Work with many people around you.
6. Enjoy social gatherings just to be with people.
7. Work better when people praise you.
8. Be a leader at a social affair.
9. Speak in public.
10. Pay little attention to details.
11. Be exceedingly careful in meeting people.
12. Keep a personal diary.
13. Keep quiet when out in company.
14. Believe that rumors are important.
15. Take an active part in all conversations going on around you. . . .[2]

A third study shows the same fact, namely, that there is a low correlation between different measures of introversion. Applying four different measures of extroversion to the same group, Guthrie[3]

[1] Later studies by other investigators have failed to verify this point. One study found that 1,000 subjects followed the normal curve of distribution. Root, A. R., and Root, E. B. A study of the Neymann-Kohlstedt diagnostic test for introversion-extroversion. *J. abnorm. (soc.) Psychol.*, 1932, 26, 415–421.

[2] From Neymann, C. A., and Kohlstedt, K., *op. cit.* Reprinted by permission from the Journal of Abnormal and Social Psychology.

[3] Guthrie, E. R. Measuring introversion and extroversion. *J. abnorm. (soc.) Psychol.*, 1927, 22, 82.

found that no one measure has an appreciable correlation with any other.

Summary.—Taken as a group these studies convey the impression that the terms "extroversion" and "introversion" are rough descriptive epithets; that extroversion and introversion are specific traits linked to specific activities and situations; that few individuals show these traits as general tendencies, but that they tend to be present in varying amounts and in varying patterns; that any particular questionnaire test, dealing as it does with a specific group of situations or items, must not be given general significance, since another battery of items might yield (and has been found experimentally to do so) a different score, even though in the opinion of the one who constructs the test the items are equally valid measures of introversion.

Personality tests dealing with aggressiveness, honesty, perseverance, self-assurance, suggestibility, emotionality, interests, prejudices, radicalism, etc., lead one to similar conclusions. Few of the tests have high reliability or predictive value. There is still no easy substitute for the painstaking and extended study of the individual, and in addition to the experimental indications there are logical considerations which should lead us to expect the individual to be a unique phenomenon. The pigeonholing, stereotyping habit of mind, whereby we think of the people we meet in terms of the stereotypes of the public prints or of literature (a Roosevelt, a Lincoln, a Scrooge, a Hamlet, a Machiavelli), may do for the purposes of everyday discourse but it is not a very accurate language. It would seem that such a term as "introvert" is the psychologist's stereotype: it represents a galaxy of traits fairly well defined, which no one individual will show in all situations in the extreme degree. The important question will not be "Is this individual an introvert?" but rather "In what situations and in what degree is this individual introverted?"

The Clinician's Types.—In the psychiatric field, where we deal with marked deviation from the normal, one would expect to find the clearest demarcation of types. And if we find that a group of depressives (or of schizophrenics, hystericals, etc.) have many traits in common we should not be surprised, for it is on the basis of their reactions that the classification into the various psychiatric categories is made. The fact is, however, that even here we commonly find many "mixed" cases which are not easily pigeonholed; and when we

add to this fact the fluid character of mental disease categories (styles of diagnosis have a way of changing through the years), and the uncertain causal basis for many of the disorders, we shall be forewarned against taking the pathological extremes as pointing out the basic dimensions of personality according to which the normal population is to be measured.

Prepsychotic Personality.—It is interesting to note, however, that it is not merely after the psychosis has developed that personalities differ in characteristic fashion; we may find the typical reactions

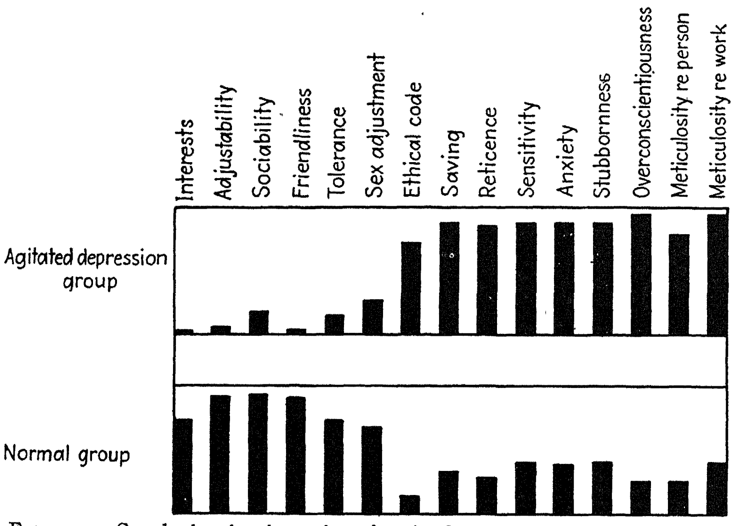

FIG. 111.—Graph showing intensity of traits for ten normal persons and ten patients with agitated depression. (*From W. B. Titley. Prepsychotic personality of patients with agitated depression. Arch. Neurol. Psychiat.*, 1938, 39, 333–342. *By permission of the publishers.*)

extending back into adolescence and even early childhood. For example, ten patients with agitated depression were studied by Dr. W. B. Titley,[1] who compared them with a similar number of normal subjects in the following traits: interests, adjustability, sociability, friendliness, tolerance, sex adjustment, ethical code, saving, reticence, sensitivity, anxiety, stubbornness, overconscientiousness, meticulosity in regard to person and in regard to work. His findings are presented graphically in Fig. 111 and show a sharp contrast between the two groups.

[1] Titley, W. B. Prepsychotic personality of patients with agitated depression. *Arch. Neurol. Psychiat.*, 1938, 39, 333–342.

As children the patients were characterized as shy, retiring, as models of conduct. As adolescents they were apt to be serious, "old for their age," with a marked sense of what is right and proper. They were generally reticent and showed little depth of feeling. Change (as in going to college, transfer to a new city, etc.) was difficult, and often productive of anxiety. As a worker the patient in this group was found to be diligent, dependable, exact, inclined to adhere to rigid routines and to precedent. He was found to be frugal in his expenditures, cautious in his investments, apt to delay marriage (if, indeed, he married) and then to show less than normal desire for children. Sexual demands were minimal, and he seemed to desire respect rather than love. He was inclined to be humorless, unforgiving, and found little time for recreation. He was characteristically pessimistic, had few friends, and participated in social affairs in a very limited way (and then largely from a compulsion to do the right thing). He was apt to be concerned about his health, and about the health of the members of his family. As a housewife this sort of person was upset by any disorder, and her duties were usually discharged in a fixed manner.

Serious, hard-working, with narrow interests, such a personality—if coupled with high intelligence—frequently can show solid accomplishments. If of low intelligence, he becomes the small-minded drudge, useful in some detailed work that requires clocklike adherence to prescribed routine.

A similar constellation of traits was found in a group of patients diagnosed as involutional melancholia;[1] but both these groups were in marked contrast (with respect to these traits) to the normal group, and to patients with manic-depressive psychosis. (The latter corresponded closely to the normal.)

Attempts have likewise been made to investigate the personalities of epileptics, schizophrenics, and even the migraine patient, but they have not been conspicuously successful in differentiating clear-cut types.[2] On the one hand, there is found to be a great deal of overlapping between these various groups (so far as the traits studied permit comparison), as well as between these groups and the normal individuals who were studied. On the other hand, comparison of the work of different investigators is rendered difficult because their

[1] Titley, W. B. Prepsychotic personality of patients with involutional melancholia. *Arch. Neurol. Psychiat.*, 1936, 36, 19–33.

[2] Knopf, Olga Preliminary report on personality studies in thirty migraine

theoretical predilections have led them to select totally different categories. One analyst will classify his patients according to oral, anal, narcissistic, or genital trends, whereas another will look for inferiority feelings, hypochondriasis, output of energy, aggression, introversion, etc.

In the absence of better evidence it seems wise to look upon these "types" as the clinician's stereotype, as "classical" descriptions or reference points from which the individual case may be expected to depart in greater or lesser degree. Any given case might conceivably show, therefore, depressive, schizophrenic, and hysterical features. The categories are not rigidly exclusive.

The Neurotic Personality.—The popularization of psychological—and in particular psychoanalytic—knowledge has brought the word "neurotic" into our daily vocabulary. We characterize the excessive emotionality or abnormal shyness of our friends, the anxious overconcern of a mother, as neurotic; and the physician who is confronted by a patient with an obscure alimentary or cardiac complaint will sometimes dismiss it (with a tinge of contempt) as *merely* a neurotic symptom, indicating thereby that "there is nothing really organic" the matter. For the layman the term implies an evaluation: the weak, the dependent, the excitable, the anxious, the seclusive (as well as those who are too dependent upon a social support), the hostile and overly aggressive, the "show-off," the rigid, and the disorganized—in fact, all those who deviate too widely from the norm (which we take for granted)—fall into this category. For the physician the term implies both a type of therapy and a type of causation; on the one hand, neither medication nor operative procedures are of prime importance though either may be of indirect benefit, while, on the other hand, the disorder is viewed as a disorder of the personality, growing out of the events and experiences of a life history (conditioning) rather than from any lesion, toxic condition, etc.

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patients. *J. nerv. ment. Dis.*, 1935, 82, 270–285, 400–441.

Smalldon, J. L. Prepsychotic personality of manic-depressive patients. *Psychiat. Quart.*, 1934, 8, 129–147.

Blalock, Joseph R. Personality and catatonic dementia praecox. *Psychiat. Quart.*, 1932, 6, 625–641.

Bigelow, N. J. Prepsychotic personality of catatonic schizophrenics. *Psychiat. Quart.*, 1932, 6, 642–656.

Doolittle, Glenn. The epileptic personality—Its progressive changes among institutional cases. *Psychiat. Quart.*, 1932, 6, 89–96.

In view of such usages, can we properly speak of *the* neurotic personality? Surely our "deviates" will include as widely divergent types as that class which is cloaked in the anonymity of normality. (The so-called "functional" disorders are notoriously multiform.) Admitting all this, Dr. Karen Horney believes that there are, nevertheless, certain traits which all of these deviates possess in common, and she has attempted to link these traits to the dominant themes of our culture.[1]

Although the surface manifestations may vary widely, according to Dr. Horney the underlying trends run very much in a pattern. A combination of fear and hostility, of weakness (and inhibitions), and inordinate ambition, the neurotic characteristically shows a more than average need for affection and reassurance. He needs reassurance because he is at basis an insecure, fearful, anxious person. His hostility is frequently suppressed (denied full expression) because it is directed in the first place against those he *must* love, against those who are closest to him. Instead of frankly projecting the blame for his difficulties upon others, he may load it upon his own shoulders; but a halfhearted quality pervades all his self-accusations (as is shown by his resentment when these same criticisms are made by others).

Whether his hostility is expressed or not, it generates a fear of retaliation, and inclines the neurotic person to expect a similar hostility from others. The world he lives in is thus a much more to be feared place than the one in which the normal person dwells. The latter realizes that life is a struggle, that many people will not like him, that many will try to crowd him aside in their own struggle for place; but the normal person also knows that he can make friends, and what is most fundamental, he is confident in his ability to make a place for himself and secure those things which are satisfying. His anger and resentment when crossed, therefore, is much less intense than that of the weaker, more fearful neurotic, for whom every rebuff is a dangerous thrust aimed at a vital spot. To complicate the problem of the neurotic, he is robbed of some of his capacity by the fear of success itself; for will not his success rob him of the affection of those he defeats, and release their hostility and hate (which he, at any rate, would feel in their place)?

[1] Horney, Karen. *The neurotic personality of our time.* New York: Norton, 1937.

Dr. Horney's neurotic thus becomes "the timid soul" in a harshly competitive society. From the basic economic structure which underlies and permeates our whole society to the most intimate personal relationships, we are both individualists and competitors. Our success in solving our material and cultural needs is all too often possible only at the expense of others; and more often than not the conditions for our success lie in some large measure outside our individual control. Whereas our culture tells us that we are free individuals (and holds us responsible for our moral and social failures), that same culture often provides but precarious opportunities for us to achieve what is needful. And so in many of us there develops the feeling of isolation, of helplessness, of frustration. Where the impact of cultural factors (and economic ills) is heaviest, and where the individual is ill equipped by virtue of either a weak constitution or an unfortunate childhood, neurosis develops. Then, instead of the courageous and confident struggle against difficulties, there develops the bitter and cynical hostility, the whining cry for pity, the flight into illness, the unbridled need for self-justification, the excessive demands upon the interest, time, and resources of others. Or there may develop a passive, parasitic, inhibited attitude toward life, an attitude in which all creative powers dwindle, in which all successful (and restrained) aggression is impossible, and in which the enthusiastic pursuit of an organized life plan is impossible. Whether the neurotic takes flight into actual physical illness or into fantasies, his condition is likely to grow worse (barring good fortune, a change of circumstances, or intervention from outside). For a vicious cycle is set up: the false solutions forced upon him in his attempt to reconcile contradictory impulses (as, for example, to be loved when he can neither bring himself to accept love nor do anything to earn it) impair his capacity for further struggles. His low level of accomplishment will enhance his need for fantasy, his indulgence in fantasy (instead of more realistic acts) may worsen his factual condition. The excessive demands of the ill neurotic do not make him easier to live with, nor are they calculated to win him the very affection and reassurance that he is striving for.

The implication of this view is that "society breeds neurosis" and that the nature of the neurotic symptoms will vary with the dynamics of a culture. Factual support for this notion is given by the obser-

vations of Margaret Mead,[1] for example, who finds that the type who is normal to the Arapesh suffers social ostracism among the more aggressive Mundugumors, whereas the aggressive type among the Arapesh becomes the drifter, the hobo, the ne'er-do-well. Maladjustment (neuroticism) is, thus, a matter of the relationship between the "needs" of the individual (set up by the accidental combinations of constitution and early training) and the objectives imposed by society. From the standpoint of mental hygiene that society is "good" which produces the smallest number of deviates, and this will involve, on the one hand, the consideration of the uniqueness of the individual (his assets and liabilities) and, on the other hand, the offering of a richly varied set of goals which both fit this range of capacities and are possible of attainment.

A Concluding Note

In spite of our endeavor to improve our psychological tools—and there has been progress here—the fact remains that there is no foolproof method of studying the living person. However wise we may be in laboratory ways or in statistical devices for handling data, we shall, nevertheless, fall short in locating and diagnosing the problems of living human beings if we lack that sagacity born of a broad experience and a sympathetic understanding. The science of psychology can provide us with useful tools and with some conception of the type of thing to look for; but that final synthetic study of the individual remains—as is the case with much of the general practice of medicine—an artist's task.

Perhaps our study of psychology will have served its purpose if it has been able to correct, in some measure, our animistic heritage. We shall no longer look upon the person as determined by some anima hidden within, or as immaculately conceived and impervious to experience. In fact, we are driven to look upon what we call personality as a *dynamic relationship*. As dynamic, because it is a moving, changing, cumulative, and compounding affair. As a relationship, because it is made up of interactions between organisms and between an organism and the physical world.

No longer can we confine our observation to a peering within the biological organism or to an introspective analysis of individual

[1] Mead, Margaret. *Sex and temperament in three primitive societies.* New York: Morrow, 1935.

consciousness. While we might say that our science is rooted in biology, we must see to it that it is also oriented toward the social. For these reasons our study of the human individual must always overflow the boundaries of the physical organism which stands before us. We need to know the history of his development, his family background (and its dynamics), the goals he has assimilated from the culture which has nurtured him. To know and understand one person, even in an approximately adequate fashion, is to attain high wisdom, indeed.

GLOSSARY

A

abduction. Movement away from the median plane.

aberration, spherical. Abnormal or irregular bending of light rays on passage through a lens.

ablation. Removal of tissue.

abnormal. Maladaptive, unusual, not typical.

abscissas. Values plotted along the horizontal axis.

absolute temperatures. Temperatures expressed on a scale which begins with absolute zero ($-273.7°C.$).

absorption spectrum. An expression showing the relative amounts of light absorbed when different wave lengths are passed through an intervening medium.

abstract. To separate from concrete setting (as a general principle from particular objects which exemplify it); to consider an aspect of a situation (as, *e.g.*, in the act of classifying, one neglects all but one aspect of a situation).

accommodation. Adjustment of the lens of the eye in order to bring about a clear image.

acetylcholine. Parasympathetic hormone released when this division of the autonomic nervous system is stimulated; chemical which inhibits the heart and excites cranial and sacral endings.

achondroplastic. Type of dwarfism with shortening of limbs, enlargement of articulation.

achromatic. Colorless.

acromegaly. Abnormal development (particularly of bones of face and extremities) associated with excessive pituitary secretion whose onset occurs in maturity.

action current. Minute electrical changes occurring in nerve (or muscle) as it conducts impulses (or contracts).

activity cycle. The sequence of action from states of tension to states of relaxation.

actuarial. Statistical (*e.g.*, the actuarial prediction of risks by an insurance company).

adaptation. Adjustment of receptor to a constant stimulation.

addiction. Habituation, devotion to (as, *e.g.*, to a drug).

Addison's disease. Disorder attributed to diseased adrenal glands (usually caused by tuberculosis) in which general weakness, cardiac and gastric complaints accompany an abnormal pigmentation (bronzing) of the skin.

adiodokokinesis. Inability to execute rapidly alternating movements.

adventitious. Accidental, nonessential.

affect. A term sometimes used to designate any subjective experience but more often (as on p. 261) as a synonym for emotions.

affective. Emotional.

afferent. Pertaining to sensory impulses traveling toward a nerve center.

after discharge. Continuing volley of nerve impulses following removal of peripheral sensory stimulus, attributed to internuncial reflex circuits ("delay paths").

after-contraction. Involuntary contraction of muscles attributed to after discharge (as, *e g.*, when one has stood close to a wall, pressing the extended arm against it, and then steps away, relaxes the arm, and notes the arm slowly rise toward the horizontal position).

afterimage. A sensory experience continuing after the removal of the stimulus (attributed, in the case of vision, to persistent retinal action). *Negative afterimages* are always of the complementary color, *positive afterimages* of the same color as the stimulus.

agonist. The principal contracting muscle.

"aha-moment." The moment of insight.

albino. Lacking in normal pigmentation; with white skin and hair, pink eyes.

alienation. Deviation from the normal or usual in ideas, behavior.

alimentary. Pertaining to nourishment.

alimentary canal. Duct leading from mouth to anus.

all-or-none. Principle governing the action of the single nerve or muscle fiber. Thus, if the fiber acts at all, its acts maximally.

alvine. Pertaining to the belly or intestines.

ambiequal. Balanced or mixed type with many talents (Rorschach).

ambivert. A mixed type, neither extremely extroverted nor extremely introverted.

amblystoma. Tailed reptile, salamander.

amnesia. Loss of memory.

amoeba. Unicellular microorganism common in ponds (maximum size 0.1 mm. in diameter).

amoral. Showing neither conformity nor opposition to moral law.

amorphous. Having no definite shape.

amour propre. Self-love, self-esteem.

anabolism. Metabolic processes of building-up, repair.

anal-erotic. Pertaining to sensual satisfactions in anal zone; Freudian character type showing orderliness, tidiness, stubbornness, punctuality, frugality.

analyst. Practising psychoanalyst making use of Freudian concepts and methods.

analytic situation. Relationship between physician and patient during psychoanalysis.

anesthesia. A state of insensitivity, local or general.

anima. Soul or mind, usually conceived of as separable from the body and somehow responsible for and in control of the body's actions.

animal spirit. Galen's most rarified soul substance.

animism. The system of beliefs centering around the soul, or anima.

annelid. The biological class to which earthworms and leeches belong.

anomaly. Exceptional instance.

anoxemia. Lack of oxygen in the blood.

antagonist. Muscle opposing the action of another.

anterior. Situated in front of.

anthropoid. Manlike.

anthropomorphism. The tendency to endow animals with human attributes, capacities, intentions.

antiempirical. An emphasis in Gestalt psychology which assigns a relatively minor role to past experience, training, habits.

anus. The lower end and outlet of the rectum.

anxiety neurosis. A functional nervous disorder in which anxiety is the central feature.

aorta. The main arterial trunk leaving the heart.

apathetic. Indifferent, insensible, lethargic.

apathy. Lack of feeling, interest, energy.

aphasia. A loss in the power to formulate a language response.

apperception. The integration of new experience with that already in mind.

apperceptive mass. The background of ideas functioning in an act of perception.

Arbeitschule. Activity school in which pupils participate in such practical work as construction and gardening.

arborizations. Branchings (as of processes of nerve cells).

arterioles. Small arteries

asocial. Shy, tending to avoid group life or social contacts.

asphyxia. Condition resulting from deprivation of oxygen.

association. Linkage between experiences, responses (so that when one is present the other is recalled).

association, controlled. An association governed by direction or set (as, *e.g.*, "Give opposites").

association, free. An association in which the subject is not bound by limiting direction, and is permitted to give any verbal reaction which occurs in response to the stimulus word.

association, klang. An association based upon sound pattern rather than upon meaning.

association time. The interval between the giving of the stimulus word and the production of its associated verbal response.

asthenia. Weakness, lack of strength.

asthenic. Weak, feeble; body type with narrow, flat chest, sloping shoulders (Kretschmer).

asthma. A chronic disorder in which wheezing, labored breathing, a feeling of tightness and compression in the chest, spasmodic constriction of the bronchi, are symptoms.

astrologer. One who practices the pseudo science of astrology, claiming to trace the influence of heavenly bodies upon human affairs.

asynchronous. Not occurring at the same time.

atavism. A throwback or reversion to a more primitive ancestral form.

ataxia. Uncontrolled, incoordinated muscular action.

ataxia, locomotor. An ataxia which is caused by disease of the posterior columns of the spinal cord.

atom, hooked (of Epicurus). According to Epicurus the stored images and ideas within the mind are (like hooked atoms) capable of infinitely varied linkages and recombinations.

atrophy. A wasting away.
atropine. The active principle of belladonna, a poisonous plant.
atypical. Irregular, not usual.
autoerotism. Securing sexual gratification by oneself.
automatic activity. Mechanical and unvarying behavior requiring little or no correction and redirection; activity which functions without attention, awareness.
automatism. Mechanical response, habit, conditioned response.
automatization. The process of transforming a nascent habit (a variable reaction requiring attention) into a semiautomatic, stereotyped performance.
automaton. Mechanism imitating actions of living creature.
autonomic. Self-governing, automatic; division of the nervous system supplying glands and viscera and regulating vital functions.
autonomous. Independent.
autosuggestion. Self-administered suggestions (cf. Coué's phrase, "Day by day, in every way, I am getting better and better").
avocation. Minor occupation, hobby.
awareness. The state of experiencing, of being awake, attentive, alert.
axilla. Armpit.
axon. Nerve process carrying impulses away from the cell body (see p. 30).

B

Babinski reflex. Reflex extension of the toes (especially the great toe) in response to stroking sole of foot.
backward conditioning. Conditioning procedure in which the unconditioned response occurs slightly before the conditioned stimulus.
ballistic. Pertaining to rapid, thrown movements (in contrast with slow, halting, constantly redirected tense movements).
barium meal. A mixture of barium salts with food, which when ingested impedes the passage of X rays (thus rendering the outlines of the alimentary tract visible on the fluorescent screen).
barrier, functional. Internal factor preventing the indefinite spread of excitation into response mechanisms.
behaviorism. The attempt to treat behavior as objectively as possible, utilizing introspection as little as possible (and treating data obtained by its unavoidable use as indications for further instrumentation and measurement).
belongingness. Quality possessed by parts of a natural or familiar whole.
biceps-brachial. Muscles which flex and supinate the forearms.
biconvex. Rounded on both surfaces.
bifurcating. Separating into two branches.
bimodal. A curve of distribution of data having two modes or peaks.
binaural. Pertaining to the two ears.
Binet test. Standardized measure of mental development (see pp. 608–609).
binocular. Pertaining to the two eyes.
biological inheritance. That which is transmitted via gene and chromosome (in contrast to that transmitted via cultural or family traditions).
biometrician. One who specializes in the measurement of living forms.

biosocial. Pertaining to products of the joint action of biological and social forces.
bisexual. Possessing traits or qualities of both sexes.
bizarre. Odd, fantastic, whimsical.
bladder. Sac-like receptacle for the urine.
bound. Condition of a portion of a figure (or aspect of a stimulus) which is reacted to separately with difficulty.
brachydactyly. Abnormally short fingers or toes.
brain-stem. The portion of the brain which would remain if cerebral cortex (and adjacent white matter) and cerebellum were dissected away.
break-shock. Shock induced by opening a circuit.
breech. Buttocks.
breech presentation. Position of fetus at birth such that breech appears first.
brightness. Term used to describe variations in intensity of visual response (as distinguished from *intensity* of physical stimulus); degree to which child's mental age is in advance of his chronological age.
bronchi. The two branches of the windpipe.

C

ca. Abbreviation of *circa*, around, about.
Caesarian section. Operative removal of fetus through abdominal incision.
canalize. To draw off and give direction to.
capacity. Ability to react or to develop reactions under appropriate stimulation.
capacity, negative. Organic or experiential factors which interfere with present performance or future development.
capsulated. Enclosed in membranous envelope.
cardiogram. Tracing made by instrument for recording contractions of heart muscle.
castrate. To remove testicles; one upon whom the operation has been performed.
catabolism. Destructive metabolic changes.
catalyst. Reagent whose presence facilitates chemical action without actually combining with the substances affected.
cataract. Opacity of the crystalline lens.
catatonic. A form of insanity (dementia praecox) that commonly results in serious mental deterioration.
categorical. Absolute.
catharsis. The discharge of affect as a result of the discovery and reaction to buried complexes.
caudal. Pertaining to the tail.
cauterization. Burning.
censor. Psychoanalytic concept which symbolizes the processes of repression and resistance, a psychic force exercised by the ego.
center. A group of nerve cells having a common function.
central excitatory state. An excitatory state at the synapse persisting from 10 to 20 millisec. after stimulation, considered by some observers as evidence for the chemical character of transmission.

central inhibitory state. Similar to c.e.s., but inhibitory in character.

cephalization. The evolutionary trend toward greater concentration of nervous tissue at the head end.

cephalocaudal. Head-tail.

cerebellum. Mass of nervous tissue lying below the cerebrum and above and in back of the pons and medulla (see p. 46).

cerebral cortex. The surface layer of the cerebrum composed mainly of gray cell bodies.

cerebrectomy. Excision of the cerebrum.

cerebrum. The anterior and upper part of the brain, consisting of two hemispheres.

cervical. Pertaining to the neck.

cervical ganglion. Autonomic center in the neck region.

c.e.s. Central excitatory state.

chain reflex. Succession of reflex contractions in which the first reaction stimulates the second, etc.

chemotropism. A forced orientation in which the directing stimuli are chemical in nature.

chiasma, optic. Crossing of the optic fibers in front of the brain-stem.

chitinous. Pertaining to the tough shell of a crustacean.

chloretone. Hypnotic and local anesthetic.

chromatic aberration. Unequal bending of different wave lengths in passing through a lens.

chromosome. Threadlike structures within the cell regarded as bearing the hereditary determiners.

chronaxie. Excitation time (see p. 41).

chronaxie, constitutional. The condition of excitability to which a nerve or muscle tends to return because of its own make-up.

chronaxie of subordination. Chronaxie which has been altered by the stimulating conditions.

ciliary. Pertaining to hairlike processes (p. 327).

c.i.s. Central inhibitory state.

clairvoyant. Pertaining to the asserted power of the person in a mesmeric trance to see objects not present to the senses.

claustrophobia. Abnormally intense fear of closed spaces.

clonic. Pertaining to muscular spasm in which there is a rhythmic alternation of contraction and relaxation.

closed system. Logical system in which it is assumed that all variables relevant to a problem are present and correctly represented.

closure. The tendency for incomplete figures to be completed or to be perceived as complete.

cm. Centimeter.

coartive. Rorschach personality type, described as pedantic, melancholic, formalistic, dogmatic, with little artistic talent.

coconscious mind. An awareness or mental process parallel to and broader than our ordinary waking experience and accessible to observation only under special conditions (*e.g.*, hypnosis or automatic handwriting).

colloid. Gelatinous substance.

color, complementary. Two colors fulfill the complementary relationship when their mixture on the color wheel is gray.

color, primary. One of the color-sensitive substances on the retina; wave length which excites such substance maximally; experience which follows the joint action of these two factors.

commissural. Connecting.

common fate. Gestalt principle indicating that portions of a field having a common destiny (similar motion) tend to be seen together as parts of a figure.

compensation. A counterbalancing of a defect by a hyperfunctioning elsewhere.

complementary. (See color.)

complex. Emotionally toned experience (usually involving repressed elements) whose origins are seldom recognized and understood save as a result of considerable analysis.

complex, castration. The repressed fear of castration, usually originating in childhood fantasies.

complex, Electra. Emotional fixation of daughter upon father.

complex indicator. Characteristic of free association response which indicates functioning of a complex (see p. 275).

complex, inferiority. Emotional attitudes rooted in organic (or fancied) inferiority.

complex, Oedipus. Emotional fixation of son upon mother.

compulsion. Motivation to perform an act, often without sanction of personality as a whole.

concept. A general idea.

concrete. Pertaining to an actual and particular thing or instance.

conditional. Dependent upon circumstances.

conditioned. Trained, product of habit formation (particularly of the Pavlovian type).

conditioned reflex. Reflex reaction attached to new conditioned stimulus which has preceded the reflex on one or more previous occasions.

conditioned response. Habit established by Pavlovian procedure.

conditioned stimulus. The stimulus which acquires the power of invoking the conditioned response in Pavlov's procedure.

conditioning. The process of establishing linkages between two reaction tendencies through their repeated evocation together or in regular succession.

conditioning, backward. An unusual form of conditioning in which the uncontioned stimulus precedes the conditioned stimulus.

cones. Color-sensitive structures in the retina (see p. 121).

confabulatory. Pertaining to the highly imaginative accounts of behavior (in psychotic patient or child) in which the border line between the true and the imaginary is not clearly sensed by the raconteur.

configuration. Form, shape, pattern, organization of the perceptual field, Gestalt.

conflict (Freudian). Intrapsychic tension either between opposed forces within the id, or between id, ego, and superego; in common parlance the tensions which arise within the individual who is motivated but incapable of achieving release because of inhibiting circumstances within himself.

congenial. That which is in harmony with one's nature or desires.

congenital. That which is present at birth.

conjugate. Paired, coordinated (as in *conjugate* deviation of the eyes in which, though moving, they maintain focus on same point).

conscience. The sum of one's socially conditioned moral judgments.

conscious. Aware, awake.

constant error. Consistent unidirectional displacement of average performance.

constitution. Organic capacity (sometimes restricted to the genetically determined aspects).

consummatory. Pertaining to the final actions in the cycle of behavior which release the motivating tensions and restore the organism to equilibrium.

continence. Self-restraint (*e.g.*, with respect to the sexual passion).

contralateral. Pertaining to opposite side.

contrast. Enhanced or altered effect of the stimulus when the accompanying (or background) stimuli are markedly different in quality or intensity.

controlled association. (See association.)

controlled movement. (See movement.)

conventionalization. The tendency of recalled material to conform to the familiar cultural pattern and to the world of familiar objects.

convergence. A coming together (as of two afferents impinging upon a final common motor path).

convolutional. Pertaining to the folds (as in the gray matter of the cerebral cortex).

copulatory. Pertaining to the sexual union of male and female.

cornification. Degenerative changes (as, *e.g.*, of the cells of the mucous membrane of the vagina under the influence of the hormone oestrone) characteristic of the period of heat.

corpora striata. Collections of gray matter at the base of each cerebral hemisphere.

corpus callosum. Arched mass of white matter located at the base of the cleft between the two cerebral hemispheres and containing fibers which connect the latter.

correlation. Mathematical expression of the measured relationship between two variables. (A perfect correspondence is expressed by the figure 1.00, and no relationship at all by 0.00.)

cortex. The external layer (of cerebrum, cerebellum, adrenals).

cortex, motor. Electrically excitable area of cerebral cortex lying within and in front of the fissure of Rolando.

cortex, sensory. Portions (with exception of olfactory area) of the cortex of the cerebrum back of the fissure of Rolando, receiving afferent impulses.

cortical. Pertaining to the cortex.

cortin. Hormone of the adrenal cortex.

cosmology. Science of the cosmos (universe and its elements).

Couéism. One of the cults of autosuggestion founded by the Frenchman, Emile Coué.

covert. Hidden, requiring instrumentation if it is to be objectively studied.

CR. Conditioned response.

craniosacral. The jointly acting cranial and sacral branches (upper and lower divisions) of the autonomic system; parasympathetic system.

cranium. Bony case of the brain.
cretin. Maldeveloped dwarf with congenital deficiency of thyroid secretion.
criterion. A critical standard.
cue. Stimulus.
cue, minimal. Stimulus which is barely above the threshold.
curare. Indian arrow poison made from tropical plant (strychnos toxifera) and possessing paralyzing effects.
cutaneous. Pertaining to the skin.
cycle of activity. (See activity.)

D

de-afferented. With sensory connections severed.
death instinct. Freudian concept of the constellation of aggressive and destructive forces in the id.
decerebrate. Deprived of cerebral hemispheres.
deep reflex. Involuntary contraction produced by percussion of tendon or bone.
deep sensation. Experience induced by relatively intense local pressure or percussion.
delayed reflex. Conditioned reflex of long latency established through training in which a similar interval has obtained between conditioned and unconditioned stimuli.
delusion. A more or less systematic falsification of experience in which new data are unable to correct false premises (and are in fact so consistently misinterpreted that they are made to support the original false orientations).
demand character (of stimulus). Reaction-invoking power.
dementia praecox. Insanity afflicting the young (as well as those in middle life), characterized by bizarre productions, hallucinations, feelings of being influenced, etc., and frequently resulting in profound and irremediable deterioration.
dendrite. The many-branched rootlike receiving end of the neuron.
depressive. Phase of the manic-depressive psychosis in which the patient is melancholy, slowed up, and frequently imagines himself threatened with poverty and guilty of the unpardonable sin, etc.
dermis. The true skin.
desire. Motivation toward well-defined goal; Freud stressed the notion that such motivation may be unconscious, while behaviorists stress the physiological bases and experimental delimitation of such factors.
determinism. The assumption common to all sciences of the universal operation of law.
detritus. Waste matter from decomposition and disorganization.
deuteranope. Person suffering from color defect in which reds and greens are indistinguishable and the sensitivity to the various wave bands corresponds to that of the normal eye.
dichotomy. Division.
dichromat. Person able to distinguish two of the primary colors.
diencephalon. The midbrain, thalamus, and third ventricle.
differential threshold. The limit below which one is unable to discriminate between similar stimuli.

differentiation, inhibition of. Discriminatory reaction in which response to a circumscribed group of stimuli is maintained by regular reinforcement while reactions to other stimuli of the series are eliminated through consistent nonreinforcement.

direction. Term utilized by Maier to designate the subject's definition of his task; orientation toward goal in a reasoning experiment; the instruction stimulus which sets up sharply defined goalward tendency.

disciplinary. Pertaining to the improvement in one's general work habits or mode of conceiving brought about by training (as contrasted with specific information, skills).

disinhibition. An inhibition of an inhibition (as, *e.g.*, when a developing experimental extinction is interfered with by uncontrolled external stimulus).

disoriented. With faulty adjustment to spatio-temporal factors in one's surroundings; lack of identification of hospital, physician, date of the year, etc.

disposition, instinctive. Psychic force having the power of organizing behavior about certain main lines leading to biologically important goals; a statistically and objectively verifiable trend in native behavior.

disruptive. Disorganizing.

dissociated. Pertaining to a group of reactions split off from the main system of behavior and functioning as a more or less independent unit.

distal. Peripheral, away from center.

distance receptor. Sense organ receiving impressions from source some distance from the body surface.

distraction. Effect produced by secondary stimuli whose presence in sufficiently small amounts may increase the efficiency of well-motivated attention process, whereas larger amounts prove disruptive.

disuse. Absence of exercise.

docile. Teachable.

dolichocephalic. Longheaded.

dorsal. Pertaining to the back.

double images. (See images.)

drive. Motivating conditions (usually given objective description); term characteristically used when there is greater emphasis upon propulsive factors than upon objective sought, upon organic state than upon subjective experience.

drosophila. Fruit fly.

duodenal. Pertaining to the first part of the small intestine.

dullness. Mental retardation.

dynamic. Strong, active, related more to functional than to structural aspects; pertaining to energy or force.

dynamometer. Instrument for measuring strength of grip.

dynamometer tapping. Compression of a hand dynamometer as rapidly as possible.

dyne. Unit of force imparting velocity of 1 cm. per sec. to mass of 1 gram.

E

ecology. The study of the relations of organisms to their environment.

effect, law of. Law stressing the importance of rewards and punishments, satisfactions and dissatisfactions, in determining the course of learning.

effector. Reacting organ in the reflex arc; gland or muscle.

efferent. Pertaining to tracts bearing impulses away from the nerve center.
effort. Striving of well-motivated organism.
ego. Mental organization partially (but not wholly) separated from the id through the impact of external world; the rational, censoring faculty.
egocentric. Self-centered.
ego instinct. Self-preservative impulses.
eidetic. Pertaining to an unusually vivid form of imagery in which details are preserved with almost photographic fidelity.
Eidetiker. One who possesses eidetic imagery
eidotropy. Tendency of perceptions to take conventional forms.
Einstellung. Expectancy, attitude modifying incoming experience.
êlan vital. Vital spirit.
Electra complex. (See complex.)
electronic. Pertaining to electron (charge borne by atom).
embedded. Difficult to abstract from a functional whole.
emotion. Stirred up state of the organism with prominent autonomic features; subjective experience during such states.
emotion, disruptive. Emotion which disorganizes behavior, inhibits performance, lowers efficiency.
emotion, sthenic. Emotion which increases both vigor and endurance.
emotionality. Proneness to emotional responses.
emotivity. Synonym of emotionality.
empirical. Pertaining to experience or experiment.
empiricist. One who would explain in terms of experience.
end brush. The terminal branchings of an axon.
endocrine. Pertaining to glands of internal secretion.
endogenous. Originating within the body.
end plate. The point of connection between motor nerve fiber-and muscle.
energetics. Science of physical forces, energy transformations.
energy. Power of doing work, force-producing motion.
energy, potential. Energy possessed by a mass in virtue of its position.
energy, psychic. Mental energy or force; concept employed in the hormic psychologies of Freud and McDougall.
engram. Protoplasmic trace produced in the course of habit formation.
enucleated. Removed from enveloping case.
epidermis. The outer layer of skin.
epilepsy. Mental disorder involving characteristic attacks with loss of consciousness, with convulsive (tonic and clonic) muscle contractions.
epiphenomenon. Event that is added, superficial, nonessential.
epithelium. Surface layer cells of skin or mucous membrane.
equipotential. Of equal power.
erogenous. Pertaining to body zones whose excitation is capable of inducing sexual passion.
Eros. Life force, libido.
eroticism. Condition in which sexual impulses are exaggerated.
Ersatz. Substitution.
escape mechanism. Substitute response which permits individual to avoid facing more difficult situation.

esophagal spasm. Constriction of the muscles of the throat.

eugenics. Science of race improvement through controlling parentage.

eunuchoid. Pertaining to the castrated individual.

euphoria. Sense of well-being.

excitation time. Duration of stimulus of given intensity necessary to produce reaction in nerve or muscle.

exogenous. Originating outside the organism.

exopthalmic goiter. Enlarged thyroid accompanied by protruding eyes, palpitation of the heart, tremor, emotionality.

experience. Awareness; past training.

experimental extinction. The breaking down of a conditioned response by repetition of the conditioned stimulus without reinforcement.

extensors. Muscles which straighten flexed limb.

extirpation. Cutting out.

extratensive. Rorschach type characterized as outwardly adjusted, practical, suggestible, conventional.

extrinsic. Outer.

extrovert. Individual who is at ease socially, interested in outer events, active.

F

facilitation. Condition in which a second stimulus enhances the action under observation.

faculty. Power or capacity.

fakir. Mohammedan or Hindu holy man.

fallacy, naming. The tendency to substitute names for genuine explanations.

fantasy. Daydream, imaginary construction (consciously or unconsciously biographic) in which desires, fears, ambitions have an important determining role.

faradic. Pertaining to induced electrical current.

fatigue. Decline in efficiency of process due to action without sufficient recovery periods.

fatigue products. Waste material produced by the metabolic changes involved in muscular contractions.

f.c.p. Final common path, efferent nerve supplied by two or more afferents.

feeblemindedness. Condition of person with subaverage intelligence; I.Q. below 70.

fetus. Babe in womb after third month; young of other species at similar stage of development.

figure. Shape or form in perceptual field.

fin de siècle. End of the (nineteenth) century.

final common path. Efferent nerve supplied by two or more afferents.

fixate, eyes. To converge and accommodate the eyes for clear vision of a point in the field.

fixate, habit. To increase the probability of the occurrence of a response through repetition, reinforcement, or reward.

fixate, joint. To make a joint rigid or firm through simultaneous action of opposing muscles which are arranged about it.

fixation. An emotional attachment tha interferes with subsequent development (Freud).
flagellation. Flogging.
flexors. Muscles that bend a limb.
flexure. A bending.
flicker. Fluctuating visual response which disappears when the interruptions of light source increase in rate beyond 35 to 40 per second.
flight from reality. The substitution of fantasy (or other "escape") for the direct and rational facing of one's problems.
focalized. Focused, narrowed and directed upon a goal.
foci. Plural of focus.
fontanels. Membranous spaces a junction of cranial bones which have not closed.
formant. Pattern of frequencies emphasized by resonant cavity.
fovea. Depression in central portion of retina; point of clearest vision containing cones only.
frame of reference. The system of meanings, postulates, coordinates within which thought or action is conceived of as taking place.
fraternal twins. Twins originating from separate fertilized eggs.
free association. (See association.)
Freudian. Pertaining to the views of Sigmund Freud.
frigidity. Subaverage sexual responsiveness.
frontal association area. Section of frontal lobe having no known motor function.
frontal lobes. Sections of cerebral hemispheres in front of the fissure of Rolando.
frontal pole. The foremost section of the cerebrum in front of the premotor area.
fundamental. Frequency produced when sounding body vibrates as a whole.

G

galvanic skin reflex. Change in electrical resistance of skin (particularly under emotional stimuli).
galvanometer. Instrument for measuring strength and direction of flow of electric current.
galvanotropism. Orientation forced by stimulating electrical field.
ganglia, basal. Centers at the base of the cerebrum.
ganglion. Nerve center, group of cell bodies.
ganglion, stellate. Sympathetic center at upper thoracic level.
Ganzheit. Entirety, wholeness.
gastrocnemius. Large muscle of calf of the leg.
gelation. Solidification.
gene. Determiner of hereditary traits, chemical factor within chromosome.
gene-determined. Inherited.
general maturation. Nonspecialized development.
generalization. Tendency of conditioned responses (especially in early stages) to be aroused by stimuli other than those used in training.
genetic. Pertaining to the gene; pertaining to origin, developmental history.

geneticist. Student of inheritance.

genitals. Reproductive organs.

genius. Individual with unusual intellectual powers; individual with I.Q. of more than 175.

Gestalt. Form, figure, shape, configuration.

Gestaltist. Member of the "configurational" school in psychology, stressing wholes rather than parts; present dynamic factors rather than past experience.

gestation. Pregnancy.

gland. An organization of secreting cells.

glucose. The sugar of fruits, grape sugar.

glycogen. Animal starch.

goal direction. Orientation toward releasing stimulus (or consummatory response).

goiter. Enlargement of the thyroid.

gonads. Reproductive glands (testes in male, ovaries in female).

Graves' disease. Exophthalmic goiter.

gravitational reflex. Posture maintaining reflex.

gravity, specific. The weight of a substance compared with that of water.

gregariousness. Tendency to seek the company of others.

grid. Grating or plate used to administer shock.

ground. Background.

g.s.r. Galvanic skin reflex.

guidance. Verbal, manual, or instrumental procedure intended to decrease or eliminate errors.

gustatory. Pertaining to taste.

gyrus. Convolution.

H

habit. Learned response; reaction pattern traceable to patterns of stimulation.

habit repertoire. The sum of one's learned reactions.

habits, nest. Adaptations acquired in the course of development and fitted to a limited set of conditions which prevailed during this period.

habituation. Adaptation.

hallucination. False perception in which there is commonly no known sensory basis for the misinterpretation (*e.g.*, hearing "voices" when no speaker is present); experience with seeming objective reference which others present cannot verify.

handedness. Preference for or superior development of one hand.

hebephrenia. Type of schizophrenia characterized by silliness, bizarre ideas, mental deterioration.

hedonism. Greek doctrine teaching that pleasure is the only rational goal.

heliotropism. Orientation forced by pattern of illumination.

hemeralope. Person with night blindness (cone vision only).

hemianopsia. Loss of vision in one half of visual field.

hemispheres. Right and left halves of cerebrum (or cerebellum).

hemophilia. Abnormal tendency to hemorrhage.

Hertzian waves. Electromagnetic waves demonstrated by German physicist Heinrich Hertz.

heterochronism. State in which chronaxies of two connecting structures vary so widely that excitation is not transmitted from one to the other.

heterosexual. Pertaining to the opposite sex.

hierarchy of levels. The ordered arrangement of neural arcs so that lower (and local) segments are functionally subordinate to higher, organismic, integrations.

higher units. (See units.)

histological. Pertaining to the microscopic structure of tissues.

homeostasis. Tendency of an organism to maintain a steady state in its internal physiochemical make-up.

homosexuality. Sexual attraction towards persons of the same sex.

hormone. The chemical agent secreted by one tissue (*e.g*, endocrine gland) and capable of exciting remote tissues.

hue. Color (varying with wave lengths reaching the retina).

humanizing. Endowing with human traits.

human nature. The constellation of common human traits (attributed by some scientists to a common biological nature and by others to the shaping social institutions).

hunch. Incompletely formulated and unverified insight.

hyperactivity. Excessive functioning.

hyperglycemia. Excess of glucose in blood.

hypermnesia. Unusually good power of memory.

hyperpituitarism. Excessive activity of the pituitary.

hypertension, nervous. Tenseness; high blood pressure.

hyperthyroidism. Excessive activity of the thyroid.

hypnosis. Dreamlike state of high suggestibility induced by suggestion.

hypochondriasis. Excessive concern about one's health, with anxiety or depression.

hypoglycemia. Low sugar content in blood.

hypopituitary. Pertaining to abnormally low secretion of pituitary.

hypothalamus. Region below the thalamus.

hypothyroidism. Condition resulting from insufficient secretion of the thyroid.

hypotonia. Low muscular tonus.

hysteria. A functional mental disorder in which abnormal emotions, sensations (or anesthesias), and contractures are prominent symptoms.

hystericals. Persons afflicted with hysteria.

I

id. The source of instinctual energy (Freud).

idea. Thought, concept.

identical twins. Twins originating from a single fertilized egg.

ideology. System of beliefs about society in which the interests of a group or class have had a strong shaping influence.

idiocy. Lowest grade of mental deficiency; I.Q. below 20.

illusion. Inaccurate or distorted perception.

mage. Symbolic representation of an object; a revived sensation; orientation tendency referring to object not present to senses.

image, liminal. The pattern of altered sensory thresholds present under a given motivating condition.

image, motor. Symbolic, incipient (implicit) movement.

imagery. The representative process consisting in experiences similar to (but normally less vivid than) perceptions.

images, double. The two different impressions of the field of vision received via the two eyes.

imagination, creative. Representative process producing new organizations of experience.

imagination, reproductive. Representative process in which earlier experienced relations are held relatively constant.

imbecile. Mentally deficient person whose I.Q. falls somewhere between 20 and 50.

imperative, categorical. Unconditional command of conscience.

implication. The dynamic aspect of perception, the "pointing-beyond" or inferential process.

implicit. Hidden, not open to observation unaided by instrumentation.

impotence. Loss of sexual power in the male.

impulsiveness. Tendency to act reflexly, automatically, without deliberation.

inanition. Exhaustion from starvation.

incest. Tabooed sexual relations between near relatives.

index of refraction. Coefficient expressing deviation of light rays in passing from one medium to another of different density.

individuation. Differentiation, development into more highly structured forms.

inductive. Form of reasoning from particular to general.

inferiority complex. (See complex.)

infrared. Pertaining to wave lengths longer than those at the visible red end of the spectrum.

in-group. Group to which we belong and in whose activities we participate.

inheritance, biological. Traits transmitted via genes.

inheritance, Lamarckian. Conception of inheritance based on hypothesis that habits and experiences of one generation affect biological inheritance of succeeding generations.

inheritance, social. Traits transmitted through impact of social institutions on succeeding generations.

inherited habit. Lamarckian conception now generally discarded in biology and psychology.

inhibition. Prevention or restraint of reaction.

inhibition, external. Failure of response caused by addition of external stimulus.

innate. Inborn, inherited.

innate idea. Concept which implies that some of our notions are determined by biological inheritance and require no previous experience on the part of the individual.

innervation, reciprocal. Principle regulating innervation of antagonistic muscles so that when one contracts its antagonist relaxes.

innervation, voluntary. Innervation through higher loopline circuits characteristic of performance in which anticipation of end-result is a regulatory factor.

insanity. State in which thought and action persistently deviate from the normal to such a degree that the individual is incapable of managing his own affairs and is not accounted responsible before a court of law.

insight. The sudden perception of means-end relations, meanings; understanding; awareness of causal factors; understanding of true character of one's own motivation and behavior.

in situ. In original or natural position, on the spot.

insomnia. Inability to sleep.

inspiration. Drawing air into the lungs, inhaling.

instinct. Innate action pattern; capacity for so acting as to produce certain ends without previous experience or foreknowledge of those ends.

instinct, death. The destructive, aggressive component of the id, occasionally turned against the self, as in suicide.

instinct, ego. Self-preservative tendencies.

integration. Organization of parts into one whole, cooperative functioning of parts.

intelligence. Capacity measured by "scholastic-aptitude" tests; capacity to profit by experience; complex index of mental efficiency in which vocabulary, learning ability, retentiveness, reasoning power, ability to use symbolic reactions, ability to work rapidly, are contributory factors.

intelligence, native. Innate capacity to acquire such abilities as are sampled by the intelligence tests.

intelligence quotient. Mental age divided by chronological age.

intention. Preparatory set directed toward end reaction or goal object.

interest. Subjective determinant in attention and learning; attitude shown by the attending individual.

interneuron bond. Lowered synaptic resistance facilitating passage of impulses from one neuron to another.

internuncial. Connecting, communicating between different parts.

interoceptor. Receptor aroused by distension or emptiness of tubes and pouches of alimentary canal and other deep-lying tissues.

interstitial. Pertaining to the interspaces between tissues.

intraorganic. Within the organism.

intrapsychic. Within the mind.

intrauterine. Within the womb.

intrinsic. Inherent, essential, not accidental or derived.

introspection. A study of mental events by the person who experiences them.

introspectionist. One who pursues the subjective method (introspection) in psychology as distinguished from those observers who view (and measure) the more objective aspects of behavior.

introversion. Trait in which person's interests are turned inward.

introversive. Type described by Rorschach; inwardly differentiated, interested in theory, stable, cautious, nonsuggestible, quiet, phlegmatic, of an abstract and philosophical turn of mind.

intuition. Perception (expectancy, judgment, belief) the cues for which are unknown and for which little rational basis can be given.

in vacuo. In a vacuum.

in vitro. In glass.

involuntary. Without antecedent regulatory plan or intent.

I.Q. Intelligence quotient, mental age divided by chronological age.

irradiation. The spread of nervous discharge.

irrational. Pertaining to the impulsive act performed without plan and touched off by immediate, intense stimuli (typically with strong affective qualities); action rooted in unconscious instinctual energies (Freud).

irritability. Excitability, the capacity (in plant and animal tissues) for responding to stimulation.

isolating. Abstracting, segregating, treating apart from context.

isometric. Pertaining to measure of muscle tension made while length of muscle is held constant.

isotonic. Pertaining to record of muscle contraction made while the tension on the muscle remains constant.

J

Jocasta. Mother of Oedipus.

Jukes. Family (studied by Dugdale in 1877) in which but 20 out of 1,200 descendants learned a useful trade, and in which criminality, degeneracy, and general incompetence were rife.

K

kaleidoscopic. Going through many and varied changes of form (as, *e.g.*, the figures of a kaleidoscope).

kinesthesis. Sensing of movement.

klang association. Association based on sound rather than sense.

Kohs block test. Intelligence test in which ability to perceive and reproduce (by arranging colored blocks) designs in colors is measured.

kymograph. Instrument for recording responses (usually on smoked paper) by means of revolving drum.

L

lability. Instability, changeableness.

lactation. Secretion of milk and the suckling of young.

Laius. Father of Oedipus.

Lamarckianism. Doctrine stressing inheritance of acquired characters (habits).

larynx. The voice box, upper part of windpipe.

latency. The period of delay between stimulus and reaction.

latency period. From fifth year to puberty, period in which crude sexual interests of infancy period are relatively dormant and new interests (sublimations) emerge.

latent time. (Same as latency.)

latent period. (Same as latency.)
lateral type. Body type (Stockard) in which circumferences and horizontal measurements are larger than average, possibly of hypothyroid origin.
lateropulsion. Impulse to one side.
law of effect. Law of learning in which the strength or weakness of a connection between situation and response is viewed as determined by the satisfactions or discomforts which have previously attended this connection.
learning. Modification in behavior traceable to specific training procedures (spatiotemporal arrangements of stimuli).
learning, curve of. Curve established by plotting time (or errors) against trials.
lesion. Structural change in tissue resulting from injury or disease.
leucocytes. White blood corpuscles.
levator. Levator palpebrae superioris, muscle which raises the upper eyelid.
levels, mental. Concept typified by Freudian schema (p. 533) in which the mind is portrayed as composed of layers varying in their degree of awareness and accessibility to recall.
Leydig, cells of. Large cells within the semen-producing tubules.
libidinal. Pertaining to the libido.
libido. Psychoanalytic term referring to sexual energy, sometimes used in such a broad sense as to be equivalent to all creative energy.
ligation. Tying off.
limen. Threshold.
liminal image. An organization of thresholds of sensitivity characteristic of an organism that is expectant of (or in need of) a particular stimulus.
linear type. Body type (Stockard) in which the linear (vertical) measurements are greater than average, possibly of hyperthyroid origin.
liquidation. Process of eliminating or equilibrating emotional tensions and traumatic memories.
lobe. Rounded division of an organ.
lobectomy. Excision of a lobe.
local sign. Sensory quality which varies with the locality of the stimulus and serves as a cue for spatial adjustments.
localization. Orientation toward the stimulus, pointing reaction.
locomotor ataxia. (See ataxia)
logic-chopping. The practicising logician's attempts to cut reality to fit his forms of thought.
Lourdes, Grotto of. Catholic shrine whose healing powers are believed in by the devout.
lumbar. Pertaining to the region of the small of the back.
lymph. A colorless liquid which bathes the body cells and circulates in an independent network of vessels; the "middleman" between blood and tissues.

M

m. Meter, 39.37 in.
M.A. Mental age.
malaxate. To knead, moisten, and soften.
malingerer. One who feigns illness or disability.
malnutrition. Defective nourishment.

mammalian. Pertaining to animals which suckle their young.

mandible. Jaw.

manic. Pertaining to the mania (excitement, disorganization, stream of talk) of the manic-depressive psychosis.

manic-depressive. Type of psychosis characterized by attacks of excitement or depression.

masculinity. Complex of traits characteristic of the normal male.

mass action. Characteristic brain action in which functional capacity depends upon the amount rather than upon the location of intact tissue (Lashley).

masturbation. Self-abuse, production of orgasm by friction.

materialism. The attempt to formulate all reality in terms of matter and its organization.

matrix. Context, surroundings, supporting and inclosing situation.

maturation. Growth, development not attributable to training.

maze. A network ot pathways, some of which have dead ends, lying between a starting point and an incentive (commonly food where animal learning is studied) and used in studying the learning process.

meaning. Significance, reference, that which a present stimulus (symbol) points to or implies.

means-end. Type of relation existing between part-process and total task, between tool and the result of its employment.

mechanistic. Pertaining to machines (*i.e.*, to organizations of matter with a limited degree of freedom, whose laws of motion are known and predictable).

median. The midmost measure in any statistical distribution, as of scores.

median plane. Plane dividing the body longitudinally into two equal portions.

median visual field. The central portion of the external field from which light rays are reflected to the outer (temporal) portion of the retina.

medicine man. In the primitive tribe one who can cure, prophesy, influence or hold commerce with the spirit world.

medulla. Enlarged upper end of spinal cord.

medulla of adrenals. The central portion of the glands.

medullary sheath. White sheath surrounding nerve fiber.

medullated. Provided with myelin sheath.

medusa. Jellyfish.

Meissner corpuscles. Ovoid corpuscles found in skin of volar surface of fingers and toes.

melancholia, involutional. A depression (with agitation) developing after forty.

mêlange. Mixture, medley.

memory. The process or capacity for retaining impressions, habits; that which is retained.

memory, racial. Hypothetical reservoir of racial experience in which each individual participates by virtue of his organic make-up (Freud).

menopause. End of menstrual or reproductive life.

menses. The monthly flow from the womb.

mental. Pertaining to the mind; intellectual.

mental age. A level of mental development attained by the average child in an unselected sampling of a chronological-age group, as measured by standardized test procedure.

mental age, basal. Point in intelligence test below which all items are passed successfully.

mental energy. The sum total of the integrative and motivational forces of the personality.

mentalist. Theoretician who phrases his explanations and descriptions of human action in terms of mental processes, forces, entities.

mentor. Teacher.

mercaptan. Alcohol containing sulphur in place of oxygen.

mercuric. Gay, flighty, changeable.

mesencephalon. The middle cerebral vesicle of the embryonic brain from which develop the corpora quadrigemina and the two columns which connect cerebrum and pons.

mesial. Medial, middle.

metabolic rate. A measure of the rate of chemical change in living organisms.

metabolism. Chemical change in living tissues.

metamorphosis. Marked change in structure.

metaphysical. Pertaining to the portion of philosophy which investigates the ultimate nature of reality and examines the most fundamental concepts

meticulous. Solicitous about minute details.

metronome. Mechanical device for marking time (musical intervals).

mg. Milligrams.

midbrain. (See mesencephalon.)

migraine. Throbbing headache accompanied by visual and digestive disturbances.

millisec. Thousandths of a second.

mind. Hypothetical bearer of mental processes; modern correlate for the anima, mental processes viewed collectively.

minimal cues. Stimuli that are barely capable of inducing reactions and are frequently too near the threshold to be reported upon.

mm. Millimeters.

mnemonic. Pertaining to memory.

modal. Typical, pertaining to the most frequently recurring score in a distribution of measures.

modality. Form, category.

molar. Pertaining to the body as a whole; organismic (as contrasted with segmental).

molecular. Pertaining to part-processes.

monochromatism. Color blindness in which there is no discrimination between hues.

monocular. One-eyed.

mood. Affective state; term usually applied to states that are more persistent and less intense than those designated as emotions.

morbid. Pathological, abnormal, pertaining to disease.

Moro reflex. Neonate reflex characteristic of the first six weeks of infancy and succeeded by startle pattern; arms arched at side are brought together in front while legs move similarly.

moron. Mentally deficient person with I.Q. between 50 and 70.

morphological. Pertaining to form and structure of an organism.

motility. Power of moving.
motivation. The instigation of activity; the causal factors which prompt an activity.
motive. The anticipation of an end result which, when prefigured, prompts to action.
motoneuron. Motor fiber passing from spinal cord to effector and conveying excitatory or inhibitory impulses.
motor cell. Nerve cell and processes carrying efferent impulses to effectors.
motor cortex. Electrically excitable area in front of the fissure of Rolando: origin of descending motor fibers.
motor end plate. Junction of motor nerve and muscle.
motor fiber. Axon of motor cell.
motor image. Anticipation or recollection of movement.
movement, ballistic. (See ballistic.)
movement, controlled. Action in which both agonist and antagonist are tensed and the excursion tends to be slower than the ballistic (thus permitting correction and redirection of the path of the movement during its execution).
movement, phenomenal. (See phi-phenomenon.)
movement, tense. (Same as controlled.)
mu (μ). 0.001 mm.
mulak. Egyptian owl symbol from which our "m" originates.
muscle twitch. Brief reflex contraction to physical stimulus, as in a nerve-muscle preparation.
myelin. White sheath surrounding nerve fiber.
myelinization. The process of acquiring myelin sheath.
myoneural. Nerve-muscle.
myxedema. Disease caused by thyroid deficiency developing in adult life.
myxomatous. Pertaining to soft, mucous, tumors.

N

Nam family. Family (similar to the Jukes) of whom 784 members include 187 alcoholics, 431 licentious, 40 criminals.
naming fallacy. Tendency to assign names instead of explaining; tendency to treat the name of a process as though it were a determining entity or force.
narcissism. Undue self-regard, introversion of the libido.
native. Inborn, innate, inherited.
nativist. Theoretician who stresses role of innate factors in development.
nature, inherited. Totality of gene-determined traits, capacities.
nature, original. Inherited nature.
need. Physiological state (deficit) which stimulates persistent activity.
neocortex. Surface cells of the cerebrum.
neonate. Newborn.
nerve. Transmitting tract consisting of axon or bundle of axons bound in sheath.
nerve fiber. One of the units of transmitting nerve trunk (a single axon of a motor nerve, for example).
nerve net. Presynaptic netlike system of nervous elements in which conduction is diffuse, nonpolarized.

nervous energy. Semianimistic conception implying that motivational forces lie within nerve cells; irritability, drive.

nervous hypertension. (See hypertension.)

neural. Pertaining to nerves.

neurasthenia. Diagnostic category covering miscellaneous group of complaints such as fatigue, aches, concern about health, weakness, etc.

neuroblast. Cell which will become nerve fiber.

neurokyme. Energy-source in the nervous system that is both chemical and psychic.

neuromuscular. Pertaining to both nerve and muscle.

neuromuscular junction. Point where ending of motor axon impinges upon muscle fibril.

neuron. The nerve cell and its processes.

neuropaths. Persons with nervous disorders.

neurosis. Functional nervous disorder.

neurotic. Pertaining to neurosis; person afflicted with neurosis or portraying similar symptoms.

New Thought. An American cult seeking to improve morale of the individual through various exercises.

night blindness. Abnormally low acuity in low illumination, attributable to defective rod vision.

nocuous. Injurious.

nominal aphasia. Speech disorder in which inability to name objects is a prominent feature.

nonmotile. Stationary, nonmoving.

norm. Standard; statistically determined expression of central tendency of group of measures.

normal curve. Probability curve, form commonly assumed by data when measures of unselected population are made.

normative. Pertaining to norms, standards (statistical, ethical, etc.).

noxious. Injurious.

nuclei. Plural of nucleus; central portions of cells; clusters of nerve cells serving common function.

O

objective. Directly observable by two or more observers.

objective set. Expectancy, determining posture or "direction."

obsessive. Imperative, possessing, predominant; pertaining to recurring ideas which exclude all other considerations.

obsessive-compulsive. Pertaining to type of neurosis characterized by obsessive ideas and compulsions to repeat certain acts.

occipital. Pertaining to the back of the head.

occult. Hidden, mysterious; pertaining to semimagical practices, astrology, witchcraft, telepathy, etc.

oculomotor. Pertaining to eye movements.

Oedipus. Pertaining to legend of Oedipus who, deserted in infancy, later slew his father and unwittingly made love to his mother; complex grounded in early mother attachment.

oestrus. The rut of animals.
olfactory. Pertaining to sense of smell.
olfactory bulb. Bulbous end of olfactory nerve.
onanism. Masturbation or coitus interruptus.
ontogenetic. Pertaining to development of the individual from ovum to maturity.
optic chiasma. The crossing of the optic fibers in front of the brain stem.
optimum. Condition most favorable to life processes, growth.
oral. Pertaining to mouth zone.
oral-erotic. Pertaining to sexual feeling induced by stimuli in and about the mouth zone.
orbicular. Pertaining to an orifice.
orbicularis. Muscle closing eyelid.
ordinates. Values plotted along the vertical axis.
orgasm. Culmination of sexual act
original nature. (See nature.)
oscillograph. Instrument for photographic recording of wave form of electrical oscillations.
osculum. Mouthlike aperture.
out-group. They, the group differentiated from our own (superior, older, hostile, dependent, etc.).
ovarectomized. With ovary excised.
ovary. Reproductive organ (producing ova) in female.
overlearning. Additional learning beyond the point necessary to produce errorless recall.
overt. Open to view.
overtone. Tone given off by vibrating segment of sounding body and having frequency that is a multiple of the fundamental.
ovoid. Egg-shaped.
ovulation. Formation and discharge of ovum.
ovum. Egg, female reproductive cell whose fertilization gives rise to fetus.
oxidative. Pertaining to chemical process in which oxygen combines with another substance.
oxytocin. Trade preparation of pituitary extract (contracts uterus).

P

palpate. Examine by touch.
pan-sexualism. Type of theory which makes the sexual impulse the central explanatory concept.
papillary ridges. Eminences on skin (showing, *e.g.*, in fingerprint).
paradigm. Pattern, example.
paradoxical cold. Sensation of cold produced by heated stylus.
paramecium. Ciliated unicellular organism.
paranoiac. Person afflicted with psychosis in which delusional trends (grandeur, persecution) are prominent.
paranoid. Resembling paranoia.
parasympathetic. Cranial and sacral branches of the autonomic system.

paresthesia. Altered sensitivity (burning, pricking, tingling, crawling).

parietal. Pertaining to pair of bones forming top and side of skull; lobe of cerebrum.

partial. One of the component frequencies of a complex tone.

patellar tendon. (See tendon.)

pathology. Science of diseases.

pattern vision. Visual responses to form of stimulus.

perception. The process of becoming aware of objects, meanings, relations; the implicit response (preparatory set) induced by objects, etc.

peripheral. Pertaining to the rim, boundary, edge.

peristalsis. Wormlike progressive movements.

permeability. Capacity of being penetrated.

perseverance. Persistence.

perseveration. Tendency of a process to continue beyond the externally initiating and supporting stimuli.

personality. Individuality, totality of one's traits (usually with emphasis upon social adjustments).

perversion. Action turned from its normal goal object.

phalanx. Finger (or toe) bone.

pharynx. Throat cavity.

phase. Particular stage of a periodic series of changes.

phasic. Pertaining to the rapid contractions of muscles which move the body levers.

phenomenal movement. (See phi-phenomenon.)

philosophy. Reflection upon and critical appraisal of preexistent actions and feelings; the rationalization of reality.

phi-phenomenon. The "seen movement" produced by rapidly succeeding illumination of near-by retinal areas, illusory in character since the sources of light do not move as reported.

phlegmatic. Sluggish, apathetic.

phosphorescence. Luminous appearance.

phototropism. Orientation forced by light field.

phototropism, negative. Forced orientation away from light source.

phrenology. Theory locating mental faculties in definite brain regions and assuming that the skull measurements provide an index to the degree of development of these faculties.

phylogenetic. Pertaining to the development (evolution) of a species.

physiognomy. Pseudo science claiming to ascertain character on the basis of facial characteristics or body form.

physiological zero. Range of temperatures within which stimuli arouse no impression of warmth or coolness.

physique. Body build.

piano arm. Painful contractures in muscles used in playing (believed to be induced by faulty postures, insufficient relaxation).

pied. Confused arrangement, disordered.

pieds terminaux. Synaptic terminals from other fibers upon dendrite and cell body of a transmitting cell.

pinna. Outer flap of ear.

placenta. Afterbirth; round, flat organ connecting fetus (via umbilical cord) and mother.

plane of fixation. Plane passing through point to which eyes are accommodated.

plasticity. Capacity to modify behavior.

pleasure principle. Tendency for action and thought to strive toward pleasure and away from pain.

plethysmograph. Instrument recording changes in size of a member (such as would follow vascular or cardiac changes).

plexus. Network of nerves.

pneumographic. Pertaining to instrument for recording chest movements in breathing.

pole, frontal. Extreme forward portion of frontal lobe.

polymorphous. Having many forms.

polymorphous perverse. Having various forms none of which bear any great resemblance to the normal goal.

polyps. Coelenterates such as sea anemone, hydra.

polyuria. Excessive secretion of urine.

pons. Structure numbered 2 in Fig. 48.

positive afterimage. Visual aftereffects in which stimulating hues are retained.

positive reaction. Approach response.

postcentral. Back of the fissure of Rolando.

posterior. Towards the back.

postganglionic. Pertaining to fibers lying beyond the ganglion (toward the periphery).

posthypnotic. Pertaining to the period following the awakening from hypnotic state.

post-mortem. After death; (by analogy) after the event.

postnatal. Pertaining to the period after birth.

post-Rolandic. Pertaining to the area in back of the fissure of Rolando.

postural substrate. Underlying postures (of whose existence the individual may be quite unaware) supporting and initiating action.

posture. Position, attitude, pattern of muscular contraction in various members.

potency. Power.

Prägnanz. Gestalt law describing tendency of organizations toward simplicity, symmetry, uniformity.

precentral. In front of the central (Rolandic) fissure.

pre-conscious. The accessible portion of mental life.

predisposition. Readiness to respond in a particular manner.

preformists. Those accepting the theory that structure (shape) is determined by preexisting factors in the gene rather than by dynamic interplay of forces at the subsequent levels of development.

preganglionic. Pertaining to fiber lying between central nervous system and autonomic ganglion.

prehension. Grasping.

prelogical. Concrete, metaphorical; pertaining to type of mental process in which little use is made of logical categories.

pre-motor. In front of the motor area.

prenatal. Before birth.

prepotent. Dominant, more powerful.
prepsychotic. Pertaining to period before outbreak of psychosis.
pressure, deep. (See deep sensation.)
primary color. (See color.)
primary group. Intimate, natural, face-to-face grouping (*e.g.*, family).
primary sensory area. Portion of cortex first reached by afferent path.
prognosis. Prediction of future course of a disease.
projected. Thrown upon a surface (as, *e g.*, when an afterimage is seen as though lying upon a neutral cardboard surface before one).
projection area. Cortical surface innervated by paths relaying impulses from a particular sensory surface.
pronation. Turning palm downward.
prone. Face downward.
proprioceptive. Pertaining to impulses originating in tendon, muscle, joint.
protanope. Dichromat whose sensitivity curve resembles that for rod vision in the normal eye.
pseudaffective. Similar to an emotional response.
pseudo. False, spurious.
pseudopod. Temporary protoplasmic "foot" (or "arm") of protozoan.
psyche. Soul, anima.
psychiatrist. One who treats mental disorders.
psychic. Mental.
psychoanalysis. Freudian theory accounting for mental events on the basis of dynamic interplay of forces operating at different levels of awareness; therapeutic method founded on Freud's theory; science of unconscious mental processes.
psychoanalyst. One who follows Freudian methods of treating mental disorders.
psychogram. Graphic plotting of results of a battery of tests; personality profile.
psychoneurosis. Functional mental disorder without the severe disorientation and disorganization of the personality seen in the psychoses.
psychopathology. Science of abnormal behavior.
psychophysical. Pertaining to the relationship between physical and mental events.
psycho-physical disposition. Conception of instinctive trend as an expression of force that is both mental and physical (chemical, physiological).
psychosis. Grave mental disorder accounted as freeing the individual from liability in a criminal action.
psychotherapy. The use of suggestion, persuasion, reeducation, psychoanalysis, and other psychological procedures in the treatment of disease.
puberty praecox. Precocious sexual maturity.
punctiform. Having pointed shape.
pupate. To reach the third stage of insect development.
pure tone. (See tone.)
Purkinje cells. Large ganglion cells in cortex of cerebellum.
Purkinje effect. Shift in region of greatest brightness in spectrum as observer moves from daylight to twilight conditions.
purpose. Planned action, motive, goalward tendency, orientation with expectancy.

pyknic. Kretschmer's deep-chested, well-rounded, body type.
pyramidal. Shaped like pyramid (*e.g.*, as are the cells of descending motor fibers lying in the pre-Rolandic area).

Q

quadriceps. Large muscle of thigh.
quadriplegia. Paralysis of all four limbs.
quotient, intelligence. (See intelligence.)

R

radial. Pertaining to radius (small bone of forearm).
radiograph. X-ray picture.
rational. Reasonable, deliberative, pertaining to sound judgment.
rationale. Statement of theory, principles.
rationalization. Description which justifies.
reaction time. Interval between stimulus and response.
reactive. Pertaining to behavior which is determined by present conditions.
reality. That which exists in fact (as contrasted with that which is imagined); that which is verifiable (or socially affirmed).
reality, flight from. Substitution of implicit fantasies for actual struggle with the environment.
reasoning. Insightful behavior in novel situations with effective reality testing; deliberative (in contrast with impulsive) behavior; the drawing of inferences and implications from a perception (or diagnosis) of a situation.
recalcitrant. Resistant, refractory.
recall. The reinstatement of a previously learned reaction.
receptor, distance. Sense organ receiving impressions from source some distance from the body surface.
reciprocal innervation. (See innervation.)
reconditioning. Removal of conditioned responses and establishment of new ones in their place by Pavlovian technique.
recti. External and internal muscles attached to eyeball and rotating eye outward and inward.
rectum. Lower part of the large intestine.
redintegrative. Pertaining to the tendency to reinstate a previously perceived pattern in its entirety when only a portion is presented to the senses.
reference. The orienting or pointing function of a symbol.
reference, frame of. (See frame of reference.)
reflex. Involuntary reaction via lower "loop line"; hypothetical behavior unit involving receptor, afferent and efferent nerve fibers, effector.
reflex, Babinski. (See Babinski.)
reflex, chain. (See chain reflex.)
reflex circuit. Self-stimulating circuit in which the reaction of the effector provides stimulation for further action in the same effector.
reflex, conditioned. (See conditioned reflex.)
reflex, deep. (See deep reflex.)
reflex, delayed. (See delayed reflex.)

reflex, galvanic skin. (See galvanic skin reflex.)
reflex, gravitational. Posture-maintaining reflexes.
reflex, Moro. (See Moro reflex.)
reflex, scratch. Alternate flexion and extension of leg to tactual stimulus on flank.
reflexologist. Student of reflex action and its conditioning.
refraction, index of. (See index.)
refractory period. Period following reaction in which no response can be elicited.
regimen. Methodic plan of living (dieting, eating, sleeping, etc.)
regression. Return to form of behavior characteristic of an earlier and more primitive stage of development.
reify. To convert a concept into a thing; to make an aspect into a cause.
reinforcement. The process of insuring that a reaction occurs by providing requisite stimulating conditions.
release, consummatory. The relaxation of tensions which occurs when motivating stimuli are removed (or equilibrating stimuli are acquired).
release phenomena. Exaggeration of reactions of lower centers when higher (inhibitory) arcs are excised or rendered nonfunctional.
releasing stimulus. Equilibrating stimulus terminating cycle of behavior and causing relaxation of the motivating tensions.
reliability. Characteristic of a measure or observation that is readily reproduced whenever the procedure is repeated.
reorganization. Change in behavior when new relations between stimuli become determinative.
repertoire. Stock, store, the sum of one's learned equipment.
repression. Inhibition, act of relegating to the unconscious, exclusion of painful and unpleasant from awareness (or expression).
reproductive. Pertaining to duplication (reactivation of) previous response; pertaining to process of sexual generation.
resident control. Intraorganic stimuli directing movements.
resistance. Attitude of patient which interferes with uncovering of unconscious memories (or acceptance of psychoanalytic interpretation).
resistance, synaptic. Delay or impedance imposed by discontinuity between neural elements upon the passage of a nerve impulse.
retardation. Slowing of rate of mental development (evidenced by I.Q. below 100).
retina, temporal. Outer portion of retina receiving stimuli from median visual field.
retinal elements. Rods and cones.
retroactive. Affecting what has occurred earlier.
reverie. Daydreaming.
rheobase. Value representing the lowest intensity of stimulation of indefinite duration that will still excite a response.
rheotropism. Orientation forced by moving retinal images.
rote. Pertaining to mechanically exact repetition and recall.
roundabout solution. Type of solution in which performer cannot move directly toward goal or incentive.

S

sacral. Pertaining to the sacrum (large triangular bone at lower end of spinal column); lowest division of the autonomic system.

sagacity. Capacity to select essence of a problem; good judgment.

sagittal. Pertaining to antero-posterior vertical section.

salamander. Lizard.

saltatory. Pertaining to abrupt changes, leaping.

sarcoplasm. Interfibrillar muscle substance.

satiety. Surfeit, fullness, state in which desire is absent.

satisfyingness. Quality of being able to fulfill demands, desires.

saturation. Quality of color that is free from admixtures of grays.

satyriasis. Excessive sexual desire in male.

scatter. Range of scores.

schema. Postural model of situation, integrated pattern of expectancies.

schizophrenia. Psychosis (see dementia praecox.)

scratch reflex. (See reflex.)

sea anemone. Flowerlike polyp with fleshy cylindrical body and tentacle-encircled mouth.

séance. Sitting, session devoted to occult manifestations.

second-order conditioning. Procedure in which previously formed conditioned response replaces the usual unconditioned reflex and serves as a basis for further conditioning.

segmental response. Reaction involving limited section of organism.

selection. The process of eliminating errors and fixating successes; function of attention process which emphasizes certain items in the perceptual field and neglects others.

self-correlation. Measure of agreement between two versions of the same test, or between two applications of the same test on different occasions, when the same population is tested.

semantic aphasia. Speech disturbance in which meaning of speech seems more affected than the elements composing it.

seminal vesicles. Vessels containing semen (impregnating fluid of male reproductive organs).

seminiferous. Carrying semen.

senility. Old age; mental and physical changes (weakness, forgetfulness, etc.) characteristic of old age.

sensation. Awareness produced by sensory stimulation (commonly contrasted with fully developed perceptions in which meaning plays more prominent part).

sensation, deep. Experience produced by relatively intense local pressure or percussion.

sensing. Becoming aware of, feeling.

sensitivity, differential. Capacity to discriminate between similar stimuli.

sensorium. The entire sensory apparatus; mind; cerebral cortex.

sensory fatigue. Rise in threshold of sense organ through repeated stimulation (attributed to exhaustion of reactive substance).

sensory fiber. Afferent nerve process bearing impulses toward central cells.

sentiment. An organization of attitudes and emotions about an object.
set. Preparatory posture.
set, goalward. Orientation (expectancy, posture) directed toward incentive (goal object, releasing stimulus).
set, objective. Determining posture, "direction."
sex instinct. The unlearned component in the group of tendencies centering around the reproductive function.
sexuality. Sexual traits considered collectively.
shade. Mixture of hue with gray.
sibling. One of a family having same parents.
sigma. Measure of dispersion of scores; thousandth of a second.
sign. Cue directing perceptual reaction.
sign, local. (See local sign.)
sign, of reflex. The tendency to flex or extend.
silent areas. Portions of the cortex unresponsive to electrical stimulation.
similarity, objective. Physical resemblance (which may or may not be perceived).
size-weight illusion. The apparent greater weight of small dense mass when compared with large mass of lesser density and same actual weight.
skin reflex, galvanic. Change in electrical resistance of the skin (particularly under emotional stimuli).
sociality. Inclination toward social situations.
socialization. Effect resulting from conditioning to social stimuli.
solation. Process of going into solution, liquefying.
somatic. Pertaining to the body; pertaining to the central nervous system (as distinguished from autonomic).
somesthetic. Pertaining to the body sensations.
spastic. Rigid.
spay. To remove ovaries.
specific gravity. (See gravity.)
specific maturation. Growth-determined development of specific skills.
spermatozoa. Male reproductive cells, motile elements in semen capable of fertilizing ovum.
spherical aberration. (See aberration.)
sphincter. Circular band of muscle constricting an orifice.
spinal animal. Preparation in which spinal cord is transected at the upper end.
spinal reflex. Reflex action which persists following transection of the spinal cord above the segment involved.
spinal root. One of the nerves arising from the spinal cord.
spirocheta pallida. Parasitic microorganism responsible for syphilis.
spleen. Hollow oval organ behind outer end of stomach.
spontaneous recovery. Reappearance of extinguished CR following rest period in which there has been no reconditioning.
stability. Resistance to extinction.
stammering. Involuntary speech block in which antagonistic muscle groups of the speech apparatus set against one another, or in which syllables are repeated involuntarily, in staccato fashion.

standardization. Establishment of norms of performance for significant groups (*e.g.*, age, sex, educational status, etc.).

status. Position in a social group.

stellate ganglion. Large autonomic relay center at the level of first thoracic vertebra.

stentor. Trumpet-shaped protozoon.

stereotype. Conventionalized mode of perceiving; figuratively, a thought-mold.

sthenic. Strengthening, facilitating.

sternum. Breast bone extending along midline of ventral portion of thorax.

stigmata. Marks or signs.

stigmata of St. Francis. Marks upon the body imitating the wounds of the crucifixion.

stimulation, faradic. Electrical stimulation.

stimulus. That which excites a reaction.

stimulus, inhibitory. Agent which prevents or diminishes a response.

stimulus, instruction. Verbal directions given by experimenter and calculated to establish appropriate set.

stimulus, minimal. Exciting agent of intensity just above threshold.

strabismus. Condition in which eye muscles fail to bring two visual axes together upon the object attended to.

strain of convergence. Proprioceptive stimulation arising from eye muscles involved in directing eyes upon an object.

striate muscle. Skeletal muscle; contractile elements which move the bony levers of the body, innervated by central nervous system; striped muscle tissue.

striped muscle. (See striate muscle.)

structure. Perceptual organization; to organize a perceptual field.

structured. Organized into figure and ground.

Sturm und Drang. Storm and stress.

stuttering. (See stammering.)

subconscious. Pertaining to that area of behavior in which reactions are accessible only in special states or by means of special types of recall; the unverbalized reactions of which we are unaware.

subconsciousness. Subconscious processes viewed collectively.

subcortical. Pertaining to neural structures below the cerebral cortex.

subcutaneous. Under the skin.

subjective. Pertaining to the subject (*i.e.*, the one observed); pertaining to personal and private aspects of behavior which are open only to introspective study.

subjectivity. Character of a response (perception, judgment) that is unduly influenced by subjective factors or is incapable of objective verification.

subliminal. Beneath the threshold.

substrate. The supporting background (emotional, postural) of a reaction.

subvocal. Pertaining to implicit reactions in the speech apparatus.

suggestibility. Susceptibility to control by another person through manipulation of symbols.

suggestion. Process of inducing behavior in another, usually by verbal means.

summation. Additive effect of successive or simultaneous stimuli.

superego. The Freudian equivalent of conscience; the permanent expression of parental influence; agency which makes demands upon ego and forces repression.
supinating. Turning palm up.
supine. Lying upon the back.
supraliminal. Above the threshold.
suprarenal. Adrenal.
suprasensible. Beyond the range of sensory equipment.
symbol. Element of manifest dream which carries latent meaning (revealed in free association); sign, that which stands for something.
symbolic. Representative.
sympathectomized. With sympathetic system surgically severed.
sympathetic. The central division of the autonomic system.
sympathin. Hormone similar to adrenalin liberated when smooth muscle is under sympathetic stimulation.
synapse. Junction of end brush of one nerve cell with dendrite of another.
synaptic resistance. (See resistance.)
synchrony. Simultaneity.
synergists. Cooperating muscles.
synergy. Cooperation.
synovial fluid. Lubricating fluid.
syntactical aphasia. Speech disturbance in which grammatical structure is profoundly affected.

T

tabes dorsalis. (See locomotor ataxia.)
taboo. Prohibition tribally enforced and rationalized.
tachistoscopic. Pertaining to apparatus which controls exposure time of materials used in studies of attention, perception, memory.
tactile. Pertaining to sense of touch.
tactual. (See tactile.)
talent, native. Original (inherited) capacity.
tambour. Elastic membrane stretched over instrumental cavity.
tapping, dynamometer. Compression of hand dynamometer as rapidly as possible.
teleology. The science of ends; explanation in terms of purpose.
temperament. Emotionality, predominant moods (sometimes viewed as constitutionally determined).
temperature, absolute. (See absolute.)
temporal. Pertaining to lobe of cerebrum under the temple.
temporal retina. (See retina.)
tendon, patellar. Tendon stretched across kneecap and attached to quadriceps muscle.
tense movement. (See movement.)
tension, state of. Unstable organic state in which stimuli (endogenous or exogenous) continuously prompt to action; condition in which muscles are contracted and thresholds are low.

tensor tympanum. Muscle which tightens tympanum; muscle attached to sphenoid bone and handle of malleus.

terminal disk. (See pieds terminaux.)

testes. Male reproductive glands secreting semen.

tetanus. Tonic, sustained contractions.

thalamic animal. Preparation in which all parts of the nervous system above the thalamus are severed.

therapy. Branch of medical sciences devoted to discovery and application of remedies to diseased conditions.

thermal. Pertaining to heat.

thinking. Experimental or symbolic behavior (commonly, though not necessarily, implicit).

thoracic. Pertaining to the chest.

thoracolumbar. Pertaining to the middle (sympathetic) division of the autonomic.

threshold. Position in a series of stimulus-response relationships below which the stimulus intensity is too weak to evoke a reaction.

threshold, differential. Minimum perceptible difference.

threshold profile. Organization of thresholds of sensitivity within the individual.

threshold, two-point. Minimum spatial separation of two points which will permit their identification as two points.

thyroxine. Synthetic preparation of active principle of thyroid gland.

tic. A spasmodic twitching of a muscle.

timbre. Quality of tone (dependent upon component frequencies).

tint. Mixture of hue with white.

tissue need. Physiological state providing persistent stimulation.

tone. Sound produced by regular sequence of vibrations.

tone, pure. Sound which on physical analysis is found to be composed of vibrations of one frequency.

tonic. Pertaining to tonus.

tonus. State of slight continuous tension of muscle.

tourniquet. Instrument for compressing arteries and thus controlling blood flow.

toxic. Poisonous.

trace. The residual effects of neuromuscular action.

trait. Aspect of behavior abstracted for study, measurement.

trance. Half-conscious state between waking and sleeping in which person is usually suggestible.

transfer. The effect of training in one task upon the learning of other tasks more or less similar.

transference. Confidence and affection for physician experienced by patient.

transubstantiation. Conversion of blood and wine of the communion to the body and blood of Christ.

traumatic. Pertaining to injury, shock.

Traumdeutung. Interpretation of dreams.

tremor. Minute involuntary contractions (*ca.* 10 per sec.) measurably present in the "movement of holding still."

trend, anal. (See anal-erotic.)

trend, oral. (See oral-erotic.)

trephining. Cutting out a circular plug of bone from the skull.
tropism. Orientation forced upon an animal by spatial distribution of stimuli.
twins, fraternal. (See fraternal.)
twins, identical. (See identical.)
two-point threshold. (See threshold.)
type, personality. Group of traits serving as descriptive category (often assumed to have organic basis).
typology. System of classifying individuals.

U

ultrarapid. High speed.
ultraviolet. Pertaining to short waves beyond the violet end of the visible spectrum.
umbilical. Pertaining to the navel.
unconditioned. Unlearned, original, native.
unconscious. Repressed and inaccessible portion of the mind (Freud); pertaining to the acts which are forgotten, unverbalized, and of which we are unaware.
unit character. Inherited traits transmitted via gene and behaving as a unit.
units, higher. The more inclusive organizations making up habitual performance.
ur-substance. Primitive, original substance.
uterus. Womb, hollow organ within which ovum develops.
utopian. Impractical, ideal.

V

vagal. Pertaining to vagus (cranial nerve).
vaginal. Pertaining to vagina (female genital tract opening into uterus).
vagosympathetic. Vagus.
vagus. Tenth cranial nerve supplying heart, lungs, esophagus.
validation. Testing against an accepted standard.
vascular. Pertaining to blood vessels.
vasopressin. Pituitary substance constricting blood vessels.
vasto-crureus. Muscle extending leg.
vegetative system. Autonomic system.
velocity constants. Indices showing speed of change.
venous stasis. Stagnation of the blood.
ventral. Pertaining to the belly.
ventricle. Hollow cavity (*e.g.*, within the cerebrum).
vera causa. True cause.
verbal aphasia. Language disturbance in which inability to formulate speech sounds is prominent symptom.
verbalization. Formulation in words.
vermicular. Wormlike.
vestibulospinal. Tract descending from vestibular apparatus to lower reflex centers.

vibrissae. Bristles on upper lip.

vicarious functioning. Substitute action (*e.g.*, assumption of function of destroyed tract by those remaining).

vigilance. Readiness, awareness (conceived by Head as being present in some slight degree even at spinal-unconscious level).

virility. Masculinity.

viscera. Contents of body cavity.

vision, pattern Visual responses to form of stimulus.

vision, twilight. Rod vision in reduced illumination.

visualizer. One who recalls past events in visual terms.

visual purple. Substance bathing rods.

vitalism. Anti-mechanistic theory in biology which asserts that living phenomena are explainable in vital categories and not in terms of processes which are purely physical or chemical.

vividness. Clearness, outstanding quality, intensity of a response.

volar. Palmar.

volition. Act of willing.

voluntaristic. Pertaining to systematic accounts of behavior in which the concept of will is made a central factor.

voluntary. Willed, intended.

voluntary muscles. (See striate muscle.)

vulva. External female genitals.

W

Weber-Fechner law. S equals K log I (where S equals sensation, and I equals intensity of stimulus); verbally stated, the sensation is proportional to the logarithm of the stimulus.

will. Determination, choice; motivational forces viewed collectively.

Z

Zeitgeist. Spirit of the times.

zero, physiological. Range of temperatures within which stimuli arouse no impression of warmth or coolness.

INDEX

E

F

J

S